FINAL REPORT

AIR QUALITY HEALTH RISK ASSESSMENT PROCEDURES/MODEL

Prepared for
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& Environmental Sciences
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1.0 INTRODUCTION

This report was prepared by Woodward-Clyde Consultants for the Montana Department of Health and Environmental Sciences (MDHES) in accordance with the requirements of Task Order No. 5 of the master agreement between MDHES and Woodward-Clyde Consultants (MDHES Contract No. 230059). Under Task Order No. 5 Woodward-Clyde has developed a procedural model, presented herein, for assessing the potential health risks associated with exposure to air emissions from portable and stationary solid and hazardous waste incinerators. Task Order No. 5 is being conducted pursuant to the master services agreement, which specifies that Woodward-Clyde will provide the Division with technical assistance in the area of air quality health risk assessment.

Prior to proceeding, however, it is important to understand some of the background behind the master agreement between the Division and Woodward-Clyde. Over the past several years, regulatory requirements for protecting the public health and welfare from exposure to manmade pollutants have evolved with increasing public awareness and evolving public attitude and opinion. A contributing factor to these evolutions is the scientific community's ever expanding ability to measure, quantify, and predict. The ability to conduct an analysis often drives the need for the analysis to be conducted, which in turn drives the need to develop new analytical techniques and methods, thus perpetuating the cycle.

Finding itself in this environment and with a broad statutory mandate not to allow the construction and/or operation of portable and stationary solid and hazardous waste incinerators without first proving that the risk to the public would be "negligible," the Division, realizing its lack of expertise in the area of air quality related health risk assessments, sought outside assistance. This assistance took the form of the master agreement between the MDHES and Woodward-Clyde. The intent of the agreement was three-fold: (1) to assist the Division in reviewing applications to construct and operate portable and stationary hazardous waste incinerators; (2) to assist the Division in developing a suitable definition of "negligible risk"; and (3) to develop a process/procedural model for the Division and applicants to utilize in assessing the potential air quality health risks associated with operation of solid and hazardous waste incinerators.

To date, Woodward-Clyde has reviewed the air quality health risk assessment portion of two applications to operate a portable hazardous waste incinerator and assisted the Division in arriving at a suitable definition of the term "negligible risk" (Woodward-Clyde 1993). This report, along with training that Woodward-Clyde will provide to the division, represents the development of the process/procedural model pursuant to Task Order No. 5 under the master agreement.

In summary, under Task Order No. 5, Woodward-Clyde has or is in the process of performing/providing MDHES with the following tasks.

1) Identify potentially appropriate and practical air dispersion and health risk models.

2) Evaluate the models identified, providing a concise report that identifies advantages and disadvantages of each.

3) Recommend and/or design a procedure/model for MDHES to use in assessing multi-pathway health and environmental risks associated with air emissions from solid and hazardous waste incinerators.

4) Develop a standardized procedure for applicants to follow in submitting permit applications for solid and hazardous waste incinerators.

5) Develop an information request checklist for the applicant so that permitting requirements can be more readily understood and the permitting process tracked.

6) Provide appropriate documentation.

7) Meet with MDHES and provide training to MDHES on implementation of the standardized procedure and use of the information request checklist.

It is important to understand that the models and procedures we have reviewed, recommended, and developed here, represent a variety of similar approaches yet different means of obtaining the same goal, assessing the health risks associated with air emissions.

An assessment of human health risk typically starts with a simple screening procedure and, if necessary, evolves into a refined analysis using more sophisticated air dispersion and risk assessment models. If the screening analysis shows that chemicals present in facility emissions have insignificant air quality impacts and associated health risk, the proposed project could be given approval with minimal costs to both the State and the permit applicant. If, however, the screening analysis indicates emissions of chemicals requiring multipathway risk assessment, air quality impacts, or unacceptable health risk then a more refined analysis should be conducted. A refined analysis would use site-specific parameters coupled with even more sophisticated modeling techniques to remove the conservatism inherent in the screening approach used to estimate air concentrations, and to include the contribution of multipathway chemicals, if present, in the human health risk estimate. If significant air quality or health impacts are still predicted with a refined modeling assessment, then design changes in the proposed incinerator, such as the addition of air pollution control equipment, may be required.

Because we have been requested to do so, we have provided MDHES with an approach/definition of the process of assessing health risks associated with air emission and recommended/developed an appropriate and simplistic procedure for implementing that approach. We caution that the procedures we present here, as with any of the other procedures which exist, are only tools and that the blind use of these tools and the results which they produce is unwise. These procedures do not obviate the need to employ sound scientific and engineering principles and judgement as well as common sense, as applied to the situation at hand.

2.0
AIR QUALITY MODELING ISSUES WHICH INFLUENCE HEALTH RISK ASSESSMENTS

Due to the physical and real limitations of continuously monitoring the dispersion of a source's emissions, computer models are used to simulate and predict dispersion characteristics and concentrations at any given distance from the source. Using background data from just a few air quality and/or meteorological monitoring stations, together with emissions data characterizing the source, air quality impacts from a source can be predicted. The diversity of Montana's climate, terrain, and variation in source characteristics of stationary and portable solid and hazardous waste incinerators must be considered. Therefore, it is necessary to select a model or models for use in the health risk analysis which has been designed to simulate the different topographic and atmospheric situations which may exist at the site where the incinerator will be located.

Air quality models predict ground level concentrations of air pollutants given the location and strength of pollutant emissions. Air quality models use estimates or physical measurements of meteorological values and mathematical algorithms of how pollutants behave physically in the environment to predict where the pollutants are transported and resulting concentrations, and/or deposition from assumed source characteristics. An air quality model attempts to simulate the physical and chemical processes that occur in the atmosphere. It attempts to simulate the transport, dispersion, chemical transformations, and deposition of air contaminants as they travel from a source to a receptor. For purposes of estimating human health risk from airborne contaminants, an air quality model translates information about the physical properties of a specific air contaminant, its source, and the local and regional meteorological data into estimates of air concentrations and/or deposition rates at various locations. Air dispersion models can be used to predict the consequences of an action, such as redesign or addition of air pollution control devices, that could be expensive, difficult, or destructive to do in the real world. Use of models allows systematic and reproducible projections of the result of altering air emissions of chemicals.

Air quality models are founded on basic scientific principles and can be used to make policy or regulatory decisions for hypothetical situations. Three principal processes that control the fate of air contaminants as they move from a source to a receptor are advection, turbulent diffusion, and removal. Advection refers to the movement of air contaminants by wind. Diffusion describes the spreading of pollutants about the mean wind caused by rapidly fluctuating, random variations in wind speed and direction. Removal processes include chemical transformation, deposition by gravitational settling, turbulent transfer to the ground, and scavenging by precipitation.

The dispersion of pollutants is a complicated physical process that is rarely amenable to exact mathematical treatment. In addition, the representativeness of any modeling exercise is dependent upon the methods used to estimate emissions. The general steps used to evaluate the impact of potential emissions on air resources are presented in Figure 2-1. This figure illustrates the importance of beginning each analysis with a simple screening procedure and moving on to a refined analysis only if the results do not satisfy the requirements of the screening analysis.

The first step in any impact analysis exercise should be a relatively simple screening procedure. The purpose of the screening analysis is to find those sources that will clearly not cause or contribute to air quality problems with a minimum of effort. Screening models can eliminate costly computer runs of sophisticated models, since the screening models-require less input data and are based on simplistic dispersion concepts. Screening models generally consist of relatively simplistic calculations of air pollution concentrations resulting from worst-case meteorological conditions, without the complication of varying terrain or other physical features.

If a source can be shown not to cause significant air quality problems through the use of a screening model, then it is generally accepted that the use of a more refined model would lead to the same conclusion and the modeling effort may be terminated at this point (EPA, 1986a). This is due to the inherent conservatism (estimate concentrations which are higher than would be measured) which is designed into the screening models. Thus, the screening models used should predict greater impacts than a comparable refined model.

If the screening analysis indicates a potential for air quality problems, a more sophisticated air quality modeling effort should be conducted. The use of screening techniques prior to using a more refined analysis is always desirable. The use of a refined model requires detailed source characteristics inputs. Additionally, an actual, site-specific meteorological data set may be required. Refined models consist of analytical techniques that provide more specialized concentrations estimates. As a result, they provide a more refined and, at least theoretically, a more accurate estimate of source impact and the effectiveness of control strategies. The degree of added accuracy is dependent on the specific models used. Use of screening techniques followed by a refined analysis is always a best approach. Concentration and deposition estimates from a screening analysis can be used most accurately as a comparative value (build versus no-build) whereas, these estimates from more and more refined analyses can be used as an absolute value (build versus ambient standards).

Air quality modeling predicts the rate of dilution of a pollutant as it is released into air flowing over the source. Pollutants are generally considered to be entrained in the flow and take no active role in the dispersion processes themselves. The air into which the pollutant is released has some degree of turbulence associated with it. This turbulence occurs naturally due to many factors, including obstacles in the flow path and thermal buoyancy. Turbulence causes the pollutant to spread out or dilute as it is transported away from the source. The greater the degree of turbulence, the more rapid the dilution of the pollutant. Many of the air quality models use slightly different algorithms for pollutant dispersion at each incremental level of turbulence. In addition, some models account for more factors that influence dispersion than others. How the dispersion process is handled comprises the model's attributes. Major attributes of the models reviewed in this report are discussed below.

2.1 SOURCE CONFIGURATION

The three types of sources that air quality models represent are point, line, and area sources. The point source is fixed at a given location and has dimensions that are very small relative to the distances at which pollutant concentrations are evaluated. Point sources are typically stacks that remove exhaust gases from an industrial source.

Typically, point sources will comprise the majority of sources for stationary and portable solid and hazardous waste incinerators.

Line and area sources are one and two-dimensional structures, respectively, that emit pollutants at a uniform rate over their extent. Examples of line sources are a highway with vehicular traffic flowing along it, or an extended conveyor transporting material. Examples of area sources include landfills and parking lots. Some models include volume sources, which allows treatment of area and line sources with a layer and or height of a continuous release. An example of a volume source would be emissions of fugitive dust from an unpaved road.

Some models are designed to accept only one source type, while others are able to incorporate all three. The reason for classifying all three sources into these three types is the mathematical simplicity that they introduce into the model formulation.

All models assume that emissions from area and line sources are released at a given height above ground. Some models allow the specifications of this height for each source while others assume that the emission takes place at ground level or a fixed height. A point source is generally assumed to originate from the height of the stack top. Subsequent behavior of the plume is then considered to be governed by plume rise which is described by another set of mathematical formulas.

2.2 RECEPTORS

A specific purpose of air quality modeling is to predict pollutant concentrations and/or deposition values in ambient air due to emissions from a particular facility or development. To evaluate the concentration at every point around a proposed new source would be time-consuming and expensive. Thus, air quality models allow the specification of discrete receptor locations at which concentrations are to be calculated.

The selection of receptor locations is extremely important since pollutant concentrations and/or deposition are only calculated at discrete points. If a specified set of receptors does not contain at least some points close to the location of the maximum concentration, model results might be misleading. The generally recommended procedure to minimize the possibility of missing the maximum concentration is to iteratively specify a finer and finer grid of receptors around the regions of highest concentrations calculated on each model run. Additional receptors of interest to community or schools planning and development applications might be actual monitoring locations and the impact a proposed solid or hazardous waste incinerator would have at these locations.

2.3 METEOROLOGICAL DATA INPUT REQUIREMENTS

Air contaminants of concern emitted from incinerators include criteria pollutants and hazardous air pollutants. Averaging times of hazardous air pollutants depend on the contaminant, but range from 1-hour to annual averages. Averaging times of pollutants concentrations of 24 hours or less are referred to as short-term averaging times. Averaging times greater than 24 hours (typically 3-month and annual averages) are referred to as long-term averages. Air quality models are used to calculate concentrations for both short-term and long-term averaging times.

Since the short-term standards are usually associated with the worst-case concentrations expected over a given period, the models are designed so that maximum concentration can be estimated. This can be accomplished in two ways. The first technique uses the judgment and experience of the air quality modeler to estimate the worst-case meteorological conditions in the sense of any site-specific meteorological data. Typical worst-case meteorological conditions are provided in the Screen Users Guide included in Appendix A of this report. The second technique for calculating the worst-case concentration involves letting the model evaluate the concentrations for each hour of an annual period and selecting the maximum calculated value.

Meteorological data consist of parameters that affect the dispersion of pollutants in the atmosphere. Typical meteorological data input to air quality models include hourly values of wind speed, wind direction, and an indicator of atmospheric turbulence. This indicator of atmospheric turbulence is referred to as stability class. Stability classes consist of highly turbulent unstable conditions, moderately turbulent neutral conditions, and minimally turbulent stable conditions.

An additional meteorological parameter which sometimes may be required for refined modeling is the mixing height. This parameter represents the depth of the surface based layer of the atmosphere which is well mixed (moderately to highly turbulent). The atmosphere is generally well mixed only during certain conditions to a specific height. This height is determined by surface features and the amount of solar heating.

2.4 EMISSION RATE VARIABILITY

Concentration/deposition rate values predicted by an air quality model for a given receptor depend primarily on three things: (1) source characteristics; (2) meteorology, and (3) model attributes. Implicit in the source characteristics are not only the geometric configurations of the sources, but the emissions themselves. The manner in which emission rates are calculated for various source types may often be extremely subjective. Additionally, emission rates that are used in air quality models are assumed to be constant for each source. Actual emission rates can be quite variable, particularly when incinerating various materials at variable charge rates. Not taking into account cyclical release patterns and assuming that average emission rates occur over the course of an entire day causes higher concentrations to be predicted than would actually occur.

2.5 TOPOGRAPHIC CONSIDERATIONS IN MODELING

Most air quality models do not account for terrain variation. They assume the plume maintains a constant height above terrain (topography around the source is flat in all directions).

Effects of terrain manifest themselves primarily in two, somewhat related ways. As air flow encounters various obstacles, it changes the location where impacts might have been anticipated. As air flow interacts with the terrain features, the dispersive characteristics are modified as well. This change of turbulence results in a different rate of dispersion than might have been anticipated.

Most of the models which incorporate terrain do so in a simplistic way. These models assume that elevation of plume centerline (maximum concentration in the plume) changes as topographic features are encountered: they do not consider either direction change or dispersion characteristic changes. Thus, their accuracy in a complex terrain setting is questionable. This is especially true when they are used for making short-term (less than 24-hour) predictions.

Most conventional models do not describe these complicated flow patterns that occur frequently in complex terrain. Therefore, they do not accurately predict either the pollutant distribution or the resulting ground level concentrations.

2.6 REMOVAL PROCESSES

Removal of air pollutants discharged into the atmosphere refers to the reduction of mass by deposition or chemical transformations. Frequently, detailed information about the behavior of specific materials in the atmosphere is only partially known, if at all. Dioxin compounds may be formed during the combustion of certain types of fuels. After their formation, they may be emitted in the gaseous phase, in the solid phase, or a mixture of both. The relative partitioning between the gaseous and particulate phases is not known for most emitted contaminants. Once emitted into the atmosphere, further transformation can occur as a result of cooling or presence of other materials.

The two removal processes most commonly considered in risk assessments, are chemical transformations and dry deposition. The effect of chemical transformations in the atmosphere is two-fold. Materials released into the atmosphere may react to form new substances which may behave differently in the atmosphere. A second result of chemical transformation is the loss of the primary pollutant as a result of the chemical reaction. Failure to consider loss of the primary pollutant will result in an overestimate of the ambient concentration of the primary pollutant. Many air quality models have first order chemical reaction equations built into them. If the half-life of a contaminant is not known, an exponential decay is assumed. Specific chemical reaction mechanisms that are applicable to various carcinogens and toxic air contaminants emitted from solid waste incinerators have yet to be developed for use in air quality models. Nevertheless, if these removal processes can be modeled as simple, first-order reactions, then they can be accounted for in the model using empirical, chemical-specific, half-life values.

Dry deposition refers to the transfer of air contaminants from the atmosphere to the surface of the earth. Air toxic source assessments may need to perform deposition calculations to determine the exposure through various ingestion routes, including consumption of crops, drinking water, soil, and livestock that have consumed vegetation grown in the area of concern. The pollutants of concern are metals and organic compounds, such as dioxin and furan compounds, that condense on the surface of particles. The rate at which airborne material is deposited is the deposition flux, calculated by multiplying the pollutant concentration by the deposition velocity. While gravity tends to deposit larger particles (larger than 30 μm in diameter), gravity has only a small influence on particles smaller than 30 μm. Apparently, atmospheric turbulence, rather than gravity, is the dominant mechanism responsible for dry deposition of particulates smaller than 30 μm. Thus, the deposition velocity is a measure of the rate of deposition and is related to particle size, particle density, level of atmospheric turbulence, type of underlying surface, and atmospheric pollutant concentration.

Some air quality models calculate deposition velocity and flux given particle size distribution. An alternative method for computing deposition rates is to first estimate the ground-level concentration of the air contaminant and then multiply this concentration (worst-case) by deposition velocity, typically 1 to 2 centimeters per second (cm/s). For small particulates, this method tends to provide a conservative estimate of the deposition rate. For example, assume that the ground-level concentration of a particular contaminant is 20 micrograms/cubic meter ($\mu g/m^3$). By assuming a deposition velocity of 2 cm/s, the dry deposition rate would be 0.4 μm^2-s.

2.7 TRANSPORT AND DISPERSION SCHEMES

How a model considers the transport of the emissions from a release point to a receptor and how the model estimates the dispersion or dilution and removal or deposition during transport are important basic characteristics. Currently, three approaches are followed for estimating the dilution and spatial distribution of air contaminants in the atmosphere. These approaches have led to statistical models, box models, and gradient transfer or finite differentiating models (K theory) as the classes or categories of dispersion models.

Traditionally, the statistical models, the most commonly used models today, are recommended by the EPA for use in permitting and risk assessment applications. There are several reasons why statistical models are widely used. They are simple and easy to use. Input data and computer requirements are modest. They can be used to simulate dispersion over a wide range of time scales. Hourly, seasonal, or annuals average ambient air concentrations can be easily estimated using routinely available meteorological data. The models are consistent with the random nature of atmospheric turbulence.

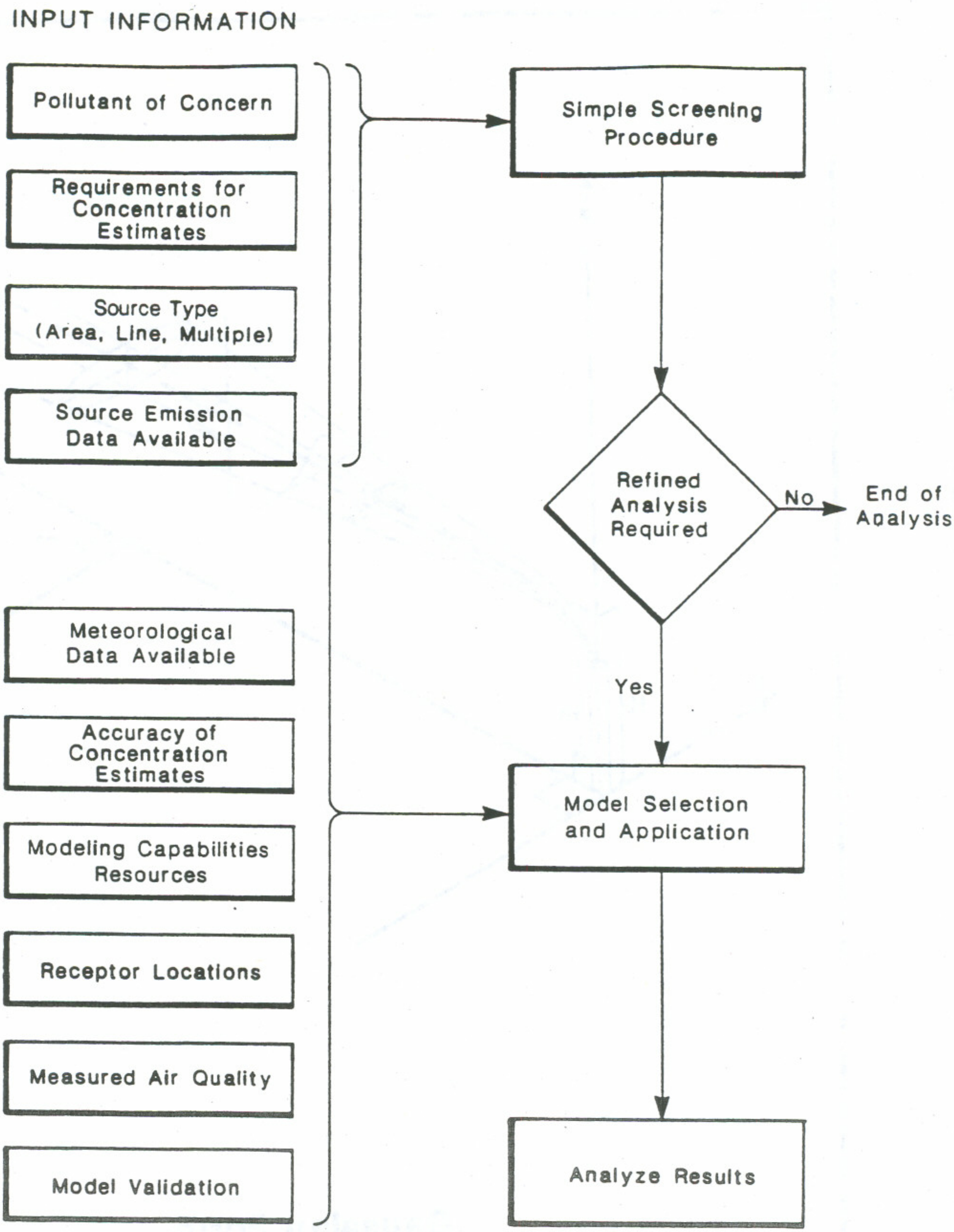
This approach assumes that atmospheric turbulence is random and that the path a particle takes in the atmosphere can be described by a statistical function. The theoretical basis for concepts now used in air quality modeling assumes that the pollutants are distributed according to a Gaussian distribution. The Gaussian form of dispersion assumes that the effluent plume spreads out from the plume centerline in Figure 2-2. Concentrations within the plume are greatest near the plume centerline and decrease with distance away from this centerline. The rate of decrease with distance is described by the normal or Gaussian distribution. The shape of the normal distribution is governed by what are known as dispersion coefficients. Small values of dispersion coefficients result in a narrow plume concentrations decreasing rapidly with cross wind distance from plume centerline. Conversely, large values of dispersion coefficients result in a wide plume with concentrations dropping slowly with the crosswind distance from the centerline.

The Gaussian formulation assumes that air flow into which the pollutant is emitted is homogeneous (constant in direction and speed along the path of the plume). This is known as the steady-state assumption and is the basis for all straight-line trajectory models.

A second method of considering transport of pollutants from a release point to a receptor is the box model. The basic box model algorithm is well documented; however, a specific computer model with regulatory approval is not available. Box models are particularly useful in simulating dispersion during drainage wind conditions in rough terrain. The model employs a box or a series of boxes that represent a drainage flow pattern. The box or combination of boxes are set up to portray the topography, meteorology, and configurations of valleys, gulches or canyons. Boxes can be treated as either slope, valley floor boxes, or upwind boxes to simulate persistent dow-valley air movement. The height and width of the boxes can be fine-tuned to the specific topography in question. The box model assumes that emission rates into a given box are instantaneously and uniformly distributed throughout the box. The amount of pollutant in each box increases to some equilibrium value determined by its wind speed and volume.

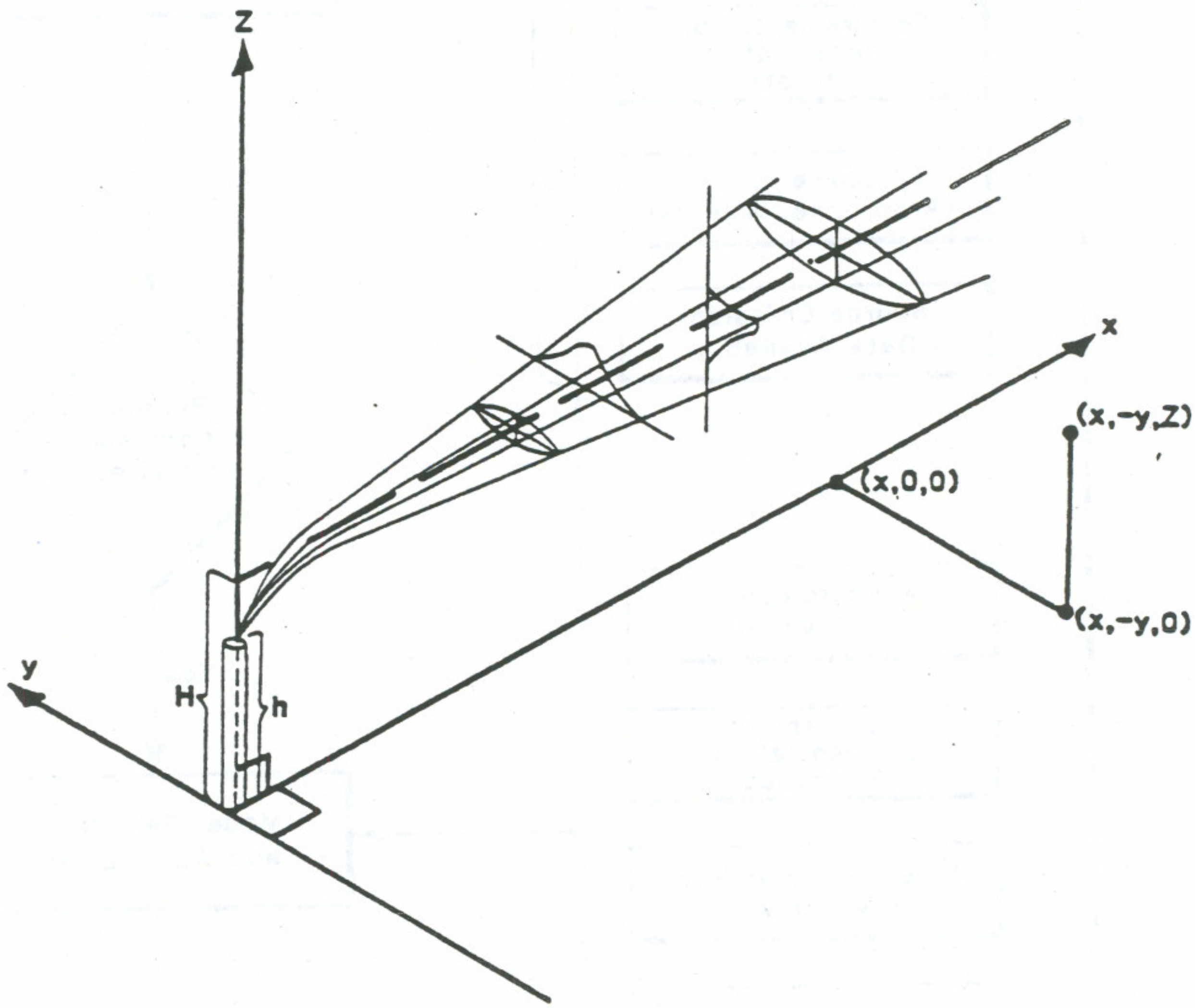
The third means of describing transport and dispersion of an effluent from a release point uses numerical techniques. These numerical models are referred to as variable trajectory, gradient transfer hypotheses, or "K theory, that leads to the classical diffusion equation. These models use numerical approximations to solve the physical equations governing the conservation of mass. This concept is borrowed from early studies in heat conduction. These models can be used to simulate dispersion in wind fields that vary in both space and time.

These models typically use a three-dimensional wind model that estimates wind speed, direction, and pollutant concentration within each grid cell. The computational domain used in a three-dimensional numerical models consists of an array of three-dimensional grid cells. Pollutants are advected from cell to cell by the wind. Topography is simulated by creating cell boundaries that prevent the air from penetrating that cell. Model results consist of concentrations of the pollutant in each cell. The predicted concentration is averaged within each cell. Due to the large amount of computer resource required, and vast amounts of input data that they can handle, these models are very expensive to use. For this reason, these models are preferred for short-term (1 to 24 hour) simulations involving many sources on a regional scale.



Steps to Evaluate Potential Emissions on Air Resources

Figure 2-1



Gaussian Form of Pollutant Transport and Dispersion

Figure 2-2

3.0
EVALUATION OF AIR QUALITY MODELS FOR USE IN HEALTH RISK ASSESSMENT

Table 3-1 presents a summary of available air dispersion models with indication of whether or not the model has the specific attributes discussed in Section 2.0. These models have been developed and are in use today to describe air quality impacts from sources such as portable and stationary solid and hazardous waste incinerators.

3.1 SCREEN2

The SCREEN2 model was developed to provide an easy-to-use method of obtaining pollutant concentration estimates. By taking advantage of the rapid growth in the availability and use of personal computers (PCs), the SCREEN2 model makes screening calculations accessible to a wide range of users. The SCREEN2 model includes several modifications and enhancements to the original SCREEN model, including updates to the code to ensure consistency with the dispersion algorithms in the Industrial Source Complex (ISC2) model. The SCREEN2 model has been included in the "Guideline on Air Quality Models (Revised)" as part of Supplement B. The EPA has written a SCREEN2 Model User's Guide (1992b) which is shown in Appendix A. This is a revised revision of EPA's SCREEN model which is discussed.

SCREEN2 runs interactively on the PC, meaning that the program asks the user a series of questions in order to obtain the necessary input data, and to determine which options to exercise. SCREEN2 can perform all of the single source, short-term calculations in the screening procedures document, including estimating maximum ground-level concentrations and the distance to the maximum, incorporating the effects of building downwash on the maximum concentrations for both the near wake and far wake regions, estimating concentrations in the cavity recirculation zone, estimating concentrations due to inversion break-up and shoreline fumigation, and determining plume rise for flare releases. The model can incorporate the effects of simple elevated terrain on maximum concentrations and can also estimate 24-hour average concentrations due to plume impaction in complex terrain using the VALLEY model 24-hour screening procedure.

Simple area sources can be modeled with SCREEN2 using a finite line segment approach, consistent with the ISC2 model. The SCREEN2 model can also be used to model the effects of simple volume sources using a virtual point source procedure. The SCREEN2 model can also calculate the maximum concentration at any number of user-specified distances in flat or elevated simple terrain, including distances out to 100km for long-range transport.

3.2 INDUSTRIAL SOURCE COMPLEX (ISC2)

ISC2 is a steady-state, multiple-source, Gaussian dispersion model designed for use with stack emission sources situated in terrain where ground-level elevations do not exceed the stack heights of the emission sources. ISC2 also treats complex phenomena such as building-induced plume downwash and the gravitational settling and deposition of particulate matter.

The ISC2 Model is recommended by EPA for use in applications such as health risk assessments of incineration. ISC2 can be used where flat terrain dominates proposed project sites. ISC2 is one of several models which are recommended by EPA for such evaluations. ISC is preferred for flat terrain applications because it incorporates algorithms for the simulation of aerodynamic downwash induced by buildings. These effects are of critical importance because many emission stacks are below Good Engineering Practice (GEP) stack height.

ISC2 uses horizontal and vertical dispersion parameters as described in Pasquill (1961) and Gifford (1960). Plume rise is calculated using the methods of Briggs (1969,1971,1975). Required meteorological input data include sequential hourly values of wind direction, wind speed, temperature, stability class, and mixing height. The values of wind speed are adjusted to stack height by standard wind shear profile equations and exponents. For cases where the effective plume height is below the mixing height, ISC2 assumes the plume is reflected at the mixing height. When the effective stack height (i.e., stack height plus plume rise) is above the mixing height, then the entire plume is assumed to be isolated above the mixing height with no ground-level impact. However, mixing height is not considered in model calculations during stable dispersion conditions.

ISC2 technical options selected for modeling typically include setting the regulatory option. Use of these options follows EPA (1986a, 1987) modeling guidance and/or sound scientific practice. An explanation of these options and the rationale for their selection is provided below. Note that certain options selected are overridden by the model when the building downwash option is selected.

The ISC2 model usually does not employ the gradual plume rise option, which accounts for downwind transport of the plume during the rising phase according to the procedures outlined by Briggs (1972). Gradual plume rise is recommended by EPA (1986a, 1987) only when there is significant terrain close to the stacks. Buoyancy-induced dispersion, which accounts for the buoyant growth of a plume, caused by entrainment of ambient air, should be included in the modeling because of the relatively warm exit temperatures and subsequent buoyant nature of the incinerator plumes. Stack-tip downwash, which adjusts the effective stack height downward following the methods of Briggs (1973) for cases where the stack exit velocity is less than 1.5 times the wind speed at stack top, should be also selected as per EPA guidance.

The calm processing option allows the user to direct the program to exclude hours with persistent calm winds in the calculation of concentrations for each averaging period. This option is generally recommended by the EPA (1986a, 1987) for regulatory applications. The ISC2 model recognizes a calm wind condition as a wind speed of 1 meter per second and a wind direction equal to that of the previous hour. The meteorological preprocessor program automatically makes this assignment to calm hours. In addition, any missing hours in the data are assigned as calm.

Past versions of the ISC2 model used a simplified downwash method to account for the effects of the aerodynamic wakes and eddies produced by plant buildings and structures. The adjustments for plume dispersion were made according to the suggestions of Huber and Snider (1976) (the Huber-Snider method). The ISC2 model applied either full building wake effect influence or none, creating a physical discontinuity between the zones. The model also used only one set of building dimensions which described the expected downwash condition for the overall site. Thus, the model was constrained due, to the limited data and research available.

The ISC model has since been modified (ISC2) to include a refined building downwash treatment that uses a method based upon the suggestions of Schulman and Hanna (1986) and Scire and Schulman (1980) (the Schulman-Scire method). If selected, and if the source height is less than or equal to the building height plus one-half the lesser of the building height or maximum projected width, the model performs the Schulman-Scire refined treatment for downwash. Use of the Schulman-Scire algorithm implies use of the following model options: gradual plume rise, no stack dip downwash, and no buoyancy induced dispersion (BID). Otherwise, the Huber-Snider method is used, as in earlier versions of ISC. Application of the Huber-Snider algorithm implies incorporation of gradual plume rise, stack dip downwash, and BID. An exception occurs when the effective plume height from momentum plume rise at two building dimensions downwind is greater than GEP height (the building height plus 1.5 times the lesser of the building height or width). In this case, the building downwash algorithm is not applied when the Huber-Snider method is selected.

Additional important changes in the Schulman-Scire scheme for building downwash include the application of a linear decay factor as a function of the effective plume height which enhances the vertical dispersion coefficient, σ_z, and modification of the plume rise due to the initial dilution of the plume with ambient air (Scire and Schulman 1980).

When applied, the Schulman-Scire downwash method requires the use of wind-direction specific building dimensions. This allows a more accurate approximation of building effects. The direction-specific dimensions are input for every ten degree sector, and are calculated as the maximum projected cross-sectional width of the overall building for that directional orientation.

3.3 VALLEY

The Valley Model is a screening technique which is primarily used for estimating the upper limits of 24-hour average pollutant concentrations due to isolated sources in rural, complex terrain. Options are provided which allow multiple sources, flat terrain, urban areas,and long-term averages to be considered.

The Valley Model is a steady-state, Gaussian plume dispersion model designed for multiple point- and area-source applications. It calculates pollutant concentrations for a joint frequency distribution designated in an array defined by six stabilities, 16 wind directions, and six wind speeds for 112 receptor sites on a radial grid of variable scale. The output concentrations are appropriate for either a 24-hour or annual period, as designated by the user. The model contains the concentration equations, the Pasquill-Gifford vertical dispersion coefficients and the Pasquill stability classes, as given by Turner. Plume rise is calculated according to Briggs. Plume height is adjusted according to terrain elevation for stable cases.

3.4 SHORTZ-LONGZ

According to the EPA (1993a), if a source is located in an urbanized complex terrain valley, then the suggested screening technique is SHORTZ for short-term averages, or LONGZ for long-term averages. These models may be used as screening techniques to predict air pollutant concentrations on terrain above stack without demonstration and evaluation. These models utilize the steady state Gaussian plume formulation for both urban and rural areas in flat or complex terrain to calculate ground-level ambient air concentrations. SHORTZ uses an annualized hourly meteorological data set to calculate short-term concentrations starting with 1 hour averages, due to emission from stacks, buildings and area sources for up to 300 arbitrarily placed sources. The LONGZ version calculates seasonal or annual concentrations using wind summary statistics to calculate ground level concentrations from up to 14,000 arbitrarily placed sources (stacks, buildings, and area sources). The models outputs consists of total concentration at each receptor due to emissions from each user specified source or group of sources, including all sources. If the option for gravitational settling is invoked, analysis cannot be accomplished in complex terrain without violating mass continuity.

3.5 COMPLEX I

The EPA (1986a, 1990a, 1993a) recommend using the COMPLEX I model to calculate concentrations on elevated terrain above stack height in rural areas. Since terrain in excess of facility stack tops in rural areas potential incineration sites in Montana, COMPLEX II should also be considered for use.

The COMPLEX I model is a multiple point source model designed for application in rural, complex terrain settings. COMPLEX I is based on the EPA MPTER model (EPA 1980) and has optional algorithms to estimate ground-level concentrations involving plume-terrain impingement, which are not contained in MPTER. This approach assumes that, under stable atmospheric conditions, the plume center line remains 10 meters above any terrain point with an elevation at or above the effective plume height.

COMPLEX I is a sector-averaging model, implying that horizontal dispersion and plume meander, resulting from variations in wind direction during an hour, are treated together by assuming uniform horizontal dispersion across a 22.5° sector (i.e., 11.25° on each side of the average hourly wind direction). COMPLEX I uses hourly-averaged wind data observed at a single location and has been found to provide a reasonably conservative technique for estimating the maximum downwind, near-source (i.e., within 50 km of the source) impact.

Limitations of COMPLEX I include no treatment of building downwash and no gravitational settling or dry depositions of particulate matter. Therefore, the EPA (1990a) developed COMPDEP as a modification to COMPLEX I to account for both wet and dry deposition. The algorithms developed by CARB (1987) were used to allow calculation of deposition velocity based on particle size and atmospheric conditions. Additional routines to enable the model to estimate pollutant concentration and deposition during periods of precipitation were also included.

COMPLEX I does not contain a methodology for estimating building wake effects. To provide COMPDEP with this capability, algorithms from the ISC2 model could be used.

3.6 RTDM

The Rough Terrain Dispersion Model (RTDM) modeling technique can provide a more refined concentration estimate if on-site wind speed and direction characteristic of plume dilution and transport are used as input to the model. In complex terrain, these winds can seldom be estimated accurately from the standard surface (10m level) measurements. Therefore, in order to increase confidence in model estimates, EPA (1993a) recommends that wind data input to RTDM should be based on fixed measurements at stack top height.

Gaussian dispersion is used with provisions to input on-site turbulence data for better estimates of σ_y and σ_z. A better agreement between model predictions and on-site monitoring data has been demonstrated as compared to VALLEY and COMPLEX I. The following variations exist between RDTM and COMPLEX I:

- Simulation of a dividing streamline height in the vicinity of the terrain during stable conditions
- Partial plume reflection from the ground during near-plume impingement cases
- Incorporation of additional on-site hourly vertical meteorological data including temperature gradient, wind speed profile exponent, wind direction shear, and turbulence data

Briggs' plume rise, buoyancy-induced dispersion, and stack tip downwash for elevated stacks is used. Limitations include no treatment of building downwash and no gravitational settling or dry depositions of particulate matter. However, recently, RTDMDEP was developed as a modification to RTDM to account for both wet and dry deposition. Like COMPDEP, the algorithms developed by CARB (1987) were used to allow calculation of deposition velocity based on particle size and atmospheric conditions. Additional routines to enable the model to estimate pollutant concentration and deposition during periods of precipitation were also included.

SUMMARY OF ATTRIBUTES FOR DISPERSION MODELS APPLICABLE TO RISK ASSESSMENT OF INCINERATORS

	SCREEN 2	ISC2	VALLEY	SHORTZ-LONGZ	COMPLEX1	RTDM
Source Configuration						
Point Sources	YES	YES	YES	YES	YES	YES
Area Sources	YES	YES	YES	YES	NO	NO
Line Sources	NO	NO	NO	NO	NO	NO
Volume Sources	YES	YES	NO	YES	NO	NO
Arbitrary Source Locations	YES	YES	YES	YES	YES	YES
Multiple Source Locations	NO	YES	YES	YES	YES	YES
Receptors						
Discrete Recptor Locations	YES	YES	NO	YES	YES	YES
Cartesian Grid	NO	YES	NO	NO	NO	NO
Polar Grid	NO	YES	YES	NO	NO	NO
Variable Recptor Heights	YES	YES	YES	YES	YES	YES
Maximum Concentration Receptor Isolated by Model	YES	YES	YES	YES	YES	YES
Meterological Data Input						
Stability Wind Rose Input	NO	ST-NO LT-YES	YES	SZ-NO LZ-YES	NO	NO
Hourly Sequential Data	NO	ST-YES LT-NO	NO	SZ-YES LZ-NO	YES	YES
Worse Case Data	YES	ST-YES LT-NO	YES	SZ-YES LZ-NO	YES	YES
Emission Factor Variability						
Variable in Time	NO	ST-YES LT-NO	NO	NO	NO	NO
Variable by Meteorology	NO	ST-YES LT-NO	NO	NO	NO	NO
Topography						
Flat Terrain Only	NO	NO	NO	NO	NO	NO
Rolling Terrain (Height Correction)	YES	YES	YES	YES	YES	YES
Terrain Above Source Release	NO	NO	YES	YES	YES	YES
Plume Rise						
Specified by User	NO	NO	NO	NO	NO	NO
Transitional Plume Rise	YES	YES	YES	YES	YES	YES
Building Downwash Effects	YES	YES	NO	YES	NO	NO
Stack Tip Downwash	YES	YES	NO	YES	YES	YES
Removal						
Exponential Decay	NO	YES	YES	YES	YES	YES
Chemical Transformation	NO	NO	NO	YES	YES	YES
Deposition other than Decay	NO	YES	NO	YES	NO*	NO*
Mixing Height Consideration	YES	YES	YES	YES	YES	YES
Transport & Dispersion						
Steady State Gaussian	YES	YES	YES	YES	YES	YES
Vertical Wind Speed Profile	YES	YES	YES	YES	YES	YES
Urban/Rural Option	YES	YES	NO	NO	YES	NO
Dispersion Coeffiecients	PG	PG/MP	PG	PG	PG	PG
Horizontal Coeffiecients	SIG	SIG	SEC	SZ-SIG LZ-SEC	SIG	STREAMLINE
Inital Mixing	YES	YES	YES	YES	YES	YES
Buoyancy Induced Dispersion	YES	YES	YES	YES	YES	YES
Long-Term Averages	NO	YES	YES	YES	YES	YES
Short-Term Averages	YES	ST-YES LT-NO	YES	SZ-YES LZ-NO	YES	YES
<1-hour	NO	ST-YES LT-NO	NO	NO	NO	NO
1-hour	YES	ST-YES LT-NO	NO	SZ-YES LZ-NO	YES	YES
3-hour	NO	ST-YES LT-NO	NO	SZ-YES LZ-NO	YES	YES
8-hour	NO	ST-YES LT-NO	NO	SZ-YES LZ-NO	YES	YES
24-hour	NO	ST-YES LT-NO	YES	SZ-YES LZ-NO	YES	YES
Maximum Short-Term Concentration	NO	ST-YES LT-NO	YES	SZ-YES LZ-NO	YES	YES

PG - Pasquill-Gifford Dispersion Coefficients

MP - McElroy-Pooler Dispersion Coefficients

NA - Not Applicable

SIG - sigma y

SEC - Sector Averaging

* New version of COMPLEX1 and RTDM called COMPDEP and RTDMDEP consider deposition

4.0 EVALUATION OF HEALTH RISK ASSESSMENT METHODOLOGIES

This section presents a brief review of some of the current methods for assessing potential human health risk from air emissions of hazardous chemicals employed by the U.S. Environmental Protection Agency and the States of California, Massachusetts and New Jersey. Following the review is a comparison of what we feel are the two most applicable methods for MDHES that address multipathway risk assessment requirements. A brief discussion on the use of exposure factors for site-specific multipathway human health risk assessments is also presented.

4.1 REVIEW OF VARIOUS METHODOLOGIES

In the past, most analyses of human health risk associated with atmospheric emissions from combustion sources has focused only on exposures occurring by direct inhalation. Studies have linked elevated levels of pollutants in soils, lake sediments, and cow's milk to atmospheric transport and deposition of pollutants from combustion sources. According to EPA, these studies indicate that deposition of airborne pollutants could result in indirect pathways of exposure for humans. The decision to evaluate an indirect exposure pathway in a risk assessment of airborne emissions from a specific facility typically depends on the physical characteristics of the actual chemicals emitted by the facility, and fate and transport in environmental media (i.e. soil, water, air). Table 4-1 and 4-2 provide a list of chemicals which if released from the source would indicate that a multipathway risk assessment should be conducted. The evaluation of indirect exposure pathways also depends on site-specific behavior patterns of persons potentially impacted by the airborne emissions, such as whether homegrown meat or locally-caught fish is consumed by residents. Therefore, an evaluation of whether an inhalation only or multipathway assessment should be one of the first steps in the health risk assessment program. Figure 4-1 presents the decision process to be followed in making this evaluation.

The first four methodologies reviewed in this section summarize the current status of EPA's proposed approach to addressing multipathway health risk assessments. EPA is in the process of issuing a single guidance document on the assessment of multipathway exposure from hazardous waste incinerator emissions. A review of California's approach for implementing the Clean Air Act follows the four EPA documents. Applicability of the EPA's Superfund program risk assessment guidance is presented next, followed by the States of California, Massachusetts and New Jersey's proposed approaches for assessing multipathway health risk from hazardous waste sites in their respective states.

Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions. EPA Office of Health and Environmental Assessment. January 1990.

According to the Environmental Reporter (May 28, 1993), site-specific risks from hazardous waste incinerators and boilers and industrial furnaces that burn the waste as fuel will be assessed under a new guidance. EPA plans to propose the new standards in September 1995 and issue the final standards in December 1996. As background in preparing the guidance, EPA will use a multi-volume series of draft reports that eventually will form the core of a risk characterization for dioxin. The risk characterization is not complete and is not expected to be made final until next year. The agency will also rely on the EPA (1990b) interim final document, the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions, in forming the risk assessment guidance. This second document is the most specific to incineration and will serve as the main guide. This methodology document seeks to provide risk assessors with the guidance necessary to estimate the health risks that result from exposure to toxic pollutants in combustor emissions by pathways other than inhalation. Whereas procedures for assessing human health risks from inhalation of pollutant emissions are well established, this methodology enables estimation of the indirect human exposures and health risks that can result from the transfer of emitted pollutants to soil, vegetation and water bodies.

This document uses cadmium and benzo(a)pyrene as examples of how these methods can be applied. The EPA has prepared a document similar to this methodology that focuses on exposures to and risks posed by dioxins present in combustor emissions. However, the equations are not available on computer spreadsheet, and new guidance on this subject was supposed to be issued in August 1993, but will not be available now until late 1995 or 1996. The document only provides guidance on non-inhalation pathways; inhalation pathway methodology is well-established and can be found elsewhere. However, this guidance presents more realistic and less conservative transport modeling than CAPCOA. This unfortunately results in more complex equations and more variables. Instead of presenting a point estimate of risk level, three scenarios are constructed that bound the estimated risk for the most likely occurrence of exposure to the population, the highest potential exposure to an individual, and a point midway between the first two.

Draft Strategy for Combustion of Hazardous Waste. U.S. Environmental Protection Agency. May 1993.

The EPA intends to reexamine its existing regulations and policies on waste combustion. A committee of EPA and State officials will address how EPA can improve its technical and permitting rules for hazardous waste combustion facilities to ensure that such facilities reflect the state-of-the-art as well as continued technical innovation. As a starting point for this effort, EPA issued a document entitled Draft Combustion Strategy (1993c). A series of long and short-term actions presented in this document are intended to serve as the starting point for discussions with the public and industry. EPA will engage in these actions designed to pursue aggressive source reduction, to enhance controls on existing combustion facilities, and to promote public participation in permitting and source reduction efforts. One of the short-term actions cited in this document is to perform site-specific risk assessments, including indirect exposure, at incinerator and boiler and industrial furnace (BIF) facilities during the permitting process.

EPA Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities. April 1994.

This EPA (1994a) guidance contains recommendations for conducting indirect exposure assessments in determining permit conditions for RCRA hazardous waste combustion facilities. It is a supplement to the EPA (1990b) report "Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions" and the EPA (1993b) draft addendum to that report. Its intent is to supplement both documents and provide some level of detail on parameter assumptions and other specific factors. Additional issues discussed in this report include:

- Who Performs the Risk Assessment- The region or state performs the risk assessment unless state law requires the owner/operator to conduct the risk assessment.

- Emissions Issues- EPA will need more extensive analysis of the chemicals identified in the emissions to estimate risks from both direct and indirect exposures, specifically the persistent and/or bioaccumulative ones that are of concern through indirect exposure routes. Three lists are attached that contain ten metals, and carcinogens and systemic toxicants from Appendix VIII (40 CFR Part 261) that have toxicity data.

- Risk Characterization Issues- Information should be presented on the range of exposures and on the use of central tendency, high end of individual risk, population risk, and risk to important subgroups. The memorandum calls for full and open discussion of uncertainties.

- Risk Management Issues- The high end individual exposure to carcinogenic chemicals should not exceed a total incremental risk level of 1×10^{-5} and for systemic toxicants (noncancer), the hazard index should be less than one. Background levels of contaminants should be included in the noncancer estimates, but only incremental risk from the facility should be considered for carcinogens.

Estimating Exposure to Dioxin-Like Compounds. EPA Office of Health and Environmental Assessment. EXTERNAL REVIEW DRAFT. June 1994.

The primary purpose of this EPA (1994b) document is to present procedures for conducting site-specific exposure assessments to dioxin-like compounds (i.e., all chlorinated dibenzodioxins and chlorinated dibenzofurans, analogous brominated compounds, and certain polychlorinated biphenyls [PCBs]). The types of sites covered in this document include incinerators, landfills and other areas involving contaminated soils. The end products of the exposure assessment procedures presented in this document are estimates of potential dose expressed in mg/kg-day. The procedures for converting these dose estimates to risk estimates are provided in a companion document on health assessment which EPA is currently publishing entitled Health Reassessment of Dioxin-like Compounds, EPA Office of Health and Environmental Assessment, 1992 (EPA 1992a).

The information contained in this document is useful for evaluating risks related to any dioxin-like chemicals emitted from a specific facility. The methodology is very similar to the methodology presented in EPA 1990c. The document does stop at exposure dose due to current controversy over EPA cancer potency values for dioxin.

CAPCOA Air Toxics Hot Spots Program Revised 1992 Risk Assessment Guidelines. AB 2588 Risk Assessment Committee of the California Air Pollution Control Officers Association (CAPCOA). October 1993.

The purpose of these guidelines is to provide risk assessment procedures for use in the preparation of the health risk assessments required under the Air Toxics "Hot Spots" Information and Assessment Act of 1987 (State of California Health and Safety Code 44360 et seq.). This law established a statewide program for the inventory of air toxics emissions from individual facilities as well as requirements for risk assessment and public notification of potential health risks. The intent of the Committee in developing the guidelines was to provide risk assessment procedures for use in the Air Toxics "Hot Spots" Program. The use of consistent risk assessment methods and report presentation should: (1) allow comparison of one facility to another; (2) expedite the review of risk assessments by reviewing agencies; and (3) minimize revision and resubmittal of risk assessments. The assumptions used in these guidelines are designed for the protection of health and to avoid underestimation of risk to the public. The risk estimates generated are useful in the comparison of one source to another and in prioritizing concerns.

The transport and exposure equations presented in Appendix E of CAPCOA are available on a personal computer spreadsheet. However, many of the transport and some of the exposure assumptions are more conservative than those in EPA (1990b, 1993b). The variable parameters used in the spreadsheet available for purchase from the State of California cannot be changed.

Risk Assessment Guidance for Superfund, Volume I- Human Health Evaluation Manual (Part A). EPA Office of Emergency and Remedial Response. December 1989.

This manual is intended to be used as guidance for all human health risk assessments conducted as part of Superfund remedial investigations and feasibility studies. The methods described in this manual may also be applicable to other assessments of hazardous wastes and hazardous materials. This interim final guidance is based on policies in the proposed revisions to the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), which were published on December 21, 1988 (53 Federal Register 51394). A final version of this manual will be published after the revised NCP is promulgated.

This guidance document was designed to evaluate potential human health risk from existing contamination of soil and water by past practices, and relies on sampling various media (air, water, soil, plants, fish, milk, and meat) to develop the concentration terms used in the exposure equations. In order to conduct a human health risk assessment for a hypothetical or pre-operational facility, or to reduce the costs of an extensive sampling program, the transport of chemicals in facility emissions should be modeled to obtain chemical concentrations in environmental media.

Superfund Exposure Assessment Manual. EPA Office of Remedial Response. April 1988

This manual serves as a source of reference concerning use of estimation procedures and modeling techniques for the analysis of potential human exposure at uncontrolled sites. It was designed to be used in conjunction with the 1986b Superfund Public Health Evaluation Manual, the predecessor to the 1989 Human Health Evaluation Manual. SEAM (Superfund Exposure Assessment Manual) describes several models for predicting emissions for chemicals from soil into air, ground water, and surface water. However, it was not designed to model airborne chemical deposition to soil, surface water, plants and biota.

Screening Procedures for Estimating the Air Impacts of Incineration at Superfund Sites, Air/Superfund National Technical Guidance Study Series. EPA Office of Air Quality. February 1992.

Various remedial alternatives selected for cleanup actions at Superfund sites are evaluated in site documents such as the Remedial Investigation/Feasibility Study (RI/FS) and Record of Decision (ROD). Evaluation of air impacts of any proposed remedial alternative is required before the remedial action is implemented. Two criteria for remedy selection stated in the NCP are: (1) compliance with Federal and State applicable or relevant and appropriate requirements (ARARs), and (2) the remedy selected is protective of human health and the environment.

This EPA (1992b) document presents predictive screening procedures for evaluation of the air impacts of onsite high temperature incineration during the detailed analysis of remedial alternatives. Results of the screening procedure are conservative. The screening procedures are generally not appropriate for use in the in-depth evaluation of existing incineration systems.

CalTOX, A Multimedia Total Exposure Model for Hazardous Waste Sites. California Environmental Protection Agency Department of Toxic Substances Control. DRAFT FOR PUBLIC COMMENT - Do not use in support of any regulatory action. June 1993.

The CalTOX model is being developed to improve decisions made on hazardous waste sites and permitted facilities regulated by the California Department of Toxic Substances Control. CalTOX is based on the intake equations found in EPA Risk Assessment Guidelines for Superfund, Human Health Evaluation. However, there are two differences. The first difference is that a compartment model has been added that predicts the movement of a chemical between air, 3 soil layers, sediment and plants at a site. The second difference is that CalTOX runs stochastically. This means that instead of estimating a single point risk level, a range of risk levels is presented. This range is based on the ranges of parameters used in computing the risks, such as body weight. A personal computer spreadsheet is under development and will be available after final comments are incorporated.

CalTOX consists of two models: the transport and transformation model, which is used to determine the dispersion of soil contaminants among soil, water and air media, and the human exposure model, which estimates potential dose from environmental media concentrations. The transport and transformation model is an emissions model. However, it does not predict the dispersion of chemicals in air to off-site locations. Once consensus on the emissions model is in place, the DTSC will address dispersion modeling to off-site receptors.

The usefulness of CalTOX is that it considers more transfer processes between air particulates, soil, surface water and plants than the CAPCOA model, and allows for a dynamic relationship between the seven compartments with conservation of mass. In this regard, the CalTOX model would probably give less conservative results than CAPCOA. However, the model is a draft report for public comment which should not be used to support any regulatory action. Recent conversations with DTSC indicate that it will not be available for at least another year.

Risk Assessment ShortForm Residential Exposure Scenario (version 1.6). Massachusetts Department of Environmental Protection, Office of Research and Standards. Final Draft. October 1992.

Chapter 21E (C.21E) of the Massachusetts General Laws is the Massachusetts Oil and Hazardous Material Release Prevention and Response Act, which became law in 1983 and was amended in 1986 and 1992 as a result of citizens initiative and legislature. This statute requires that the Department of Environmental Protection (DEP) ensure that actions be taken at state superfund sites as necessary to eliminate or abate "significant or otherwise unacceptable risk of harm to health, safety, public welfare or the environment" associated with oil or hazardous materials. The DEP promulgated the Massachusetts Contingency Plan (MCP) on October 3, 1988 to provide legally enforceable procedures for the implementation of the C.21E statute. A total excess lifetime cancer risk limit of 1×10^{-5} and a total site non-cancer hazard index limit of 0.2 are specified in the MCP (310 CMR 40.545(3)(g)3.b).

The MCP is similar to the National Contingency Plan (NCP) under the federal Superfund program. Subpart E specifies a phased approach for assessing the releases of oil or hazardous materials (OHM) and their associated risks as well as for the development and selection of remedial alternatives. Phase II investigations collect information to support development of a risk characterization. The Residential

ShortForm (discussed below) estimates only the risk of harm to human health, and can not be substituted for the entire risk characterization required under the MCP (i.e., safety, public welfare and the environment).

The Residential ShortForm spreadsheets are the first set of a series of Risk Assessment ShortForms tailored to a specific exposure scenario and/or type of disposal site; they will be revised annually. The series is one part of an ongoing effort to streamline the risk assessment process and facilitate the assessment and remediation of C.21E disposal sites. The Residential ShortForm has been designed to meet the requirements of Method 3b (multi-media), which is appropriate when: (a) residential receptors may be exposed to OHM at or from the disposal site by more than one contaminated medium, and (b) if there are not existing standards applicable to each OHM in every medium to which persons might be exposed, or specific promulgated sets of cleanup levels for the site category.

The ShortForm is a lower cost option and a rapid tool that can be used to estimate both cancer and non-cancer risks for a residential receptor assumed to live on, at, or near a disposal site. The only site-specific parameters required to run the ShortForm are exposure point concentrations for soil, drinking water and/or indoor air. The ShortForm provides standard exposure assumptions that are used to calculate risks. Carcinogenic risks are calculated for an adult resident. Noncarcinogenic risks for acute and subchronic exposure are calculated for an infant and a child, respectively. The ShortForm compares the exposure point concentrations for metals to a list of background metal concentrations. In addition, site-specific background comparisons can also be made.

Similar to the EPA Human Health Evaluation Manual (EPA 1989) and other Superfund related documents, this guidance document was designed to evaluate potential human health risk from existing contamination of soil and water by past practices, and relies on sampling various media to develop the concentration terms used in the exposure equations. The transport of chemicals in facility emissions must be modeled to obtain chemical concentrations in environmental media. However, it is available on computer spreadsheet, even though the background evaluation is unique.

Technical Manual Risk Assessment for Operating Permits (Draft). New Jersey Department of Environmental Protection and Energy (NJDEPE). Air Quality Regulation Program. August 1993.

This analysis is required for renewal or initial operating permits for facilities that emit hazardous air pollutants (HAPs) above "de minimis" thresholds defined by the New Jersey DEPE. The methodology only requires evaluation of the inhalation exposure pathway, not indirect exposure pathways. The manual states that "the inhalation route is a direct route of exposure and therefore will in most cases pose the most/greatest risk to the public." Most of the other guidances reviewed for this project state that indirect exposure pathways are often more important in terms of health risk than direct (inhalation) pathways for HAPs emitted in particulate form. Therefore, this guidance will not satisfy new EPA requirements to assess indirect pathways in human health risk assessments for hazardous waste combustion.

This approach was designed to address Title V of the Clean Air Act. The method is simple; toxicity values for HAPs and risk/hazard index calculation worksheets are provided, and only one exposure pathway is considered. Three levels of modeling ranging in complexity are presented, which can minimize modeling costs if health hazards estimated from the simpler options do not exceed health impact threshold levels defined by the NJDEPE (a cancer risk of 1×10^{-5}, and a noncancer hazard index of 10 or 5). The focus of this guidance is on modeling, not risk assessment; many air dispersion modeling parameters, such as stack height and other source parameters, receptor grids and meteorological data, are discussed in detail. Combustion of fuel oil or natural gas is not included. Annual average and 1-hour maximum modeled air concentrations of HAPs are simply multiplied by unit risk factors and reference concentrations to estimate cancer risk and noncancer hazard indices for both chronic and acute exposure periods.

Table 4-3 presents the variety of exposure pathways addressed by each of the methodologies discussed above.

4.2 COMPARISON BETWEEN EPA AND THE STATE OF CALIFORNIA GUIDANCE

Two guidance documents discussed above come closest to meeting the requirements of this project, EPA (1994a, 1993b, 1990b) Indirect Exposure to Combustor Emissions (Combustor) and CAPCOA's Risk Assessment Guidelines (CAPCOA 1993). There are many minor differences in equations and variables in the two documents, but several key differences in transport and exposure assessment assumptions are discussed here. CAPCOA methodology evaluates adult residential exposures, with the exception that ingestion of mothers milk is included in the adult exposure scenario, that are designed to result in more conservative estimates of potential health risk. EPA (1994a, 1993b, 1990b) methodology evaluates a three point range of most likely exposed in a population to highest potential exposure to an individual, and includes childhood exposures in the more conservative scenario.

CAPCOA defines a zone of impact surrounding the facility to include an area with a screening risk level of 10^{-6} or greater, based on an inhalation only estimate. EPA (1994a, 1993b 1990b) defines the area of potential impact as the area within 50 kilometers of the facility. CAPCOA recommends that actual receptor locations of residents, surface water bodies, agriculture and farm animals be determined and the coordinates used in air dispersion modeling of facility emissions. EPA (1994a, 1993b, 1990b) looks at three distances corresponding to the three point risk level range of 50, 5 and 0.2 kilometers from the facility. CAPCOA assumes a 70 year facility lifetime, while EPA (1994a, 1993b, 1990b) assumes 30, 60 and 100 years for each of the three points.

CAPCOA assumes 70 year lifetime exposure, and EPA (1994a, 1993b, 1990b) uses 16, 30 and 70 years. Soil concentrations of emitted chemicals are based on accumulation and three types of loss mechanisms in EPA (1994a, 1993b, 1990b). The transport pathway of air-to-plant is included in EPA (1994a, 1993b, 1990b), but not in CAPCOA. The agricultural yield suggested in CAPCOA is 4-20 times higher than the value suggested in EPA (1994a, 1993b, 1990b), CAPCOA considers two additional sources of chemical exposure to farm animals, inhalation and water ingestion. Exposure to contaminated surface water in EPA (1994a, 1993b, 1990b) includes the contribution of surface runoff, collected precipitation and groundwater.

Overall, CAPCOA evaluates potential human health risk more simply, but more conservatively in most cases, as shown in Table 4-4.

4.3 EXPOSURE FACTORS

Site-specific exposure factors should be used whenever possible in assessing human health risk, especially when including consumption of locally grown (within the zone of impact) vegetables, meat, dairy products, or fish. This is particularly important if there are cultural groups in the area surrounding the facility whose dietary practices differ significantly from the U.S. national average. Site-specific behavior information can be obtained by local surveys or developed from general community knowledge. If site-specific information is not available, national dietary surveys or common farming practices can be used. Unless a particular cultural group differs significantly in stature from the U.S. national average, default body weights and inhalation rates are appropriate.

If default exposure factors are needed, there are several documents available from state and federal agencies that have been approved for use at Superfund sites or to satisfy state regulatory requirements. Some exposure factors are based on typical or average behaviors and may tend to overestimate or underestimate actual risk levels, while others are more conservative and tend to overestimate risk. The applicability of the behavior depends on the design of the original study from which the data were taken. There are also articles in many peer-reviewed scientific journals which may contain more recent data on human behavior than is provided in state and federal guidance documents. Guidance documents have been reviewed and approved, but typically lag several years behind the latest scientific literature.

TABLE 4-1

SUBSTANCES TO BE EVALUATED FOR NONINHALATION PATHWAYS

Chemical	Cancer	Noncancer
Arsenic	X	X
Beryllium	X	X
Cadmium	--	X
Chlorobenzene	--	X
Chromium (hexavalent)	X	X
Chlorinated dibenzo-p-dioxins	X	X
Chlorinated dibenzofurans	X	X
2-Chlorophenol	--	X
p-Dichlorobenzene	X	X
Hexachlorobenzene	X	X
Hexachlorocyclohexanes	X	X
Lead	--	X
Mercury	--	X
Nitrosamines	X	--
Polycyclic aromatic hydrocarbons	X	--
Polychlorinated biphenyls	X	--
Pentachlorophenol	X	X
2,4,6-Trichlorophenol	X	--
2,4,5-Trichlorophenol	--	X
Zinc	--	X

Source: CAPCOA Revised 1992 Risk Assessment Guidelines, October 1993.

TABLE 4-2

SUBSTANCES TO BE EVALUATED FOR MOTHER'S MILK PATHWAY

Chlorinated dibenzo-p-dioxins
Chlorinated dibenzofurans
Polycyclic aromatic hydrocarbons
Polychlorinated biphenyls

Source: CAPCOA Revised 1992 Risk Assessment Guidelines, October 1993.

TABLE 4-3

EXPOSURE PATHWAYS

Exposure Pathway	EPA Combustor (EPA 1994a, 1993b, 1990b)	EPA Dioxin (EPA 1994b)	CA CAPCOA	EPA RAGS A (EPA 1989)	CA CalTOX	MA Short Form
Inhalation of Vapor Phase Chemicals		X	X	X	X	
Inhalation of Surface Water/ Ground Water Volatiles					X	X indoor air
Inhalation of Soil Volatiles					X	X indoor air
Inhalation of Particulate Phase Chemicals		X		X	X	
Inhalation of Resuspended Dust	X				X	
Ingestion of Water	X	X	X	X +swimming	X +swimming	X
Ingestion of Soil	X	X	X	X	X	X
Ingestion of Vegetation	X	X	X	X	X +irrigation	X
Ingestion of Meat	X	X	X	X	X	
Ingestion of Milk	X	X	X +eggs	X +eggs	X +eggs	
Ingestion of Fish	X	X	X	X	X	
Ingestion of Mothers Milk			X		X	
Dermal Contact with Soil	X	X	X	X	X	X
Dermal Contact with Water				X	X	X

TABLE 4-4

COMPARISON BETWEEN EPA'S COMBUSTOR AND CALIFORNIA'S CAPCOA GUIDELINES

Parameter	EPA (1994a, 1993b, 1990b)	CAPCOA's Guidelines
Age Group(s)	Adult and child	Adult only
Uncertainty	3 point range (most likely to highest potential)	designed to result in a conservative estimate
Zone of Impact	50 kilometers	area defined by a 1×10^{-6} screening risk
Receptor Locations	3 point range (0.2, 5, and 50 kilometers	actual site-specific locations
Facility Lifetime	3 point range (100, 60 and 30 years)	70 years
Exposure Duration	3 point range (70, 30 and 16 years)	70 years
Air-to-plant transfer	Yes	No
Agricultural yield	0.1 - 0.5	2 (4-20x higher)
Exposure to contaminated animal products	Does <u>not</u> include animal ingestion of contaminated water and inhalation of contaminated air	Includes animal ingestion of contaminated water and inhalation of contaminated air
Exposure to contaminated surface water	Includes surface runoff, collected rainwater and ground water	Does <u>not</u> include surface runoff, collected rainwater and ground water

5.0
METHODOLOGY FOR SCREENING HEALTH RISK ASSESSMENT

This section presents a proposed methodology for a screening health risk assessment to be used by the State of Montana in the permitting process of solid and hazardous waste incinerators in Montana. This methodology consists of three main segments: (1) assembling the information required to perform the analysis including filling out the attached checklist; (2) using EPA's SCREEN2 air dispersion model to calculate maximum ground level concentrations of the compounds of concern; and (3) inputing the SCREEN2 results into a FORTRAN program developed by WCC called RISKSCRN which estimates potential human health risks from the inhalation of hazardous chemicals. The goal of requiring modeling and a risk assessment as part of the permit submittal for proposed stationary or portable solid and hazardous waste incinerators is to provide the public with an estimate of the health effects they are being exposed to as the result of hazardous air pollutant (HAP) emissions from a specific facility. The assessment focuses on estimating concentrations off-site or outside the property boundary where the public would have general access.

Initially permit applicants need only consider the inhalation route of exposure. The inhalation route is a direct route of exposure and therefore will in many cases pose the greatest risk to the public. Subsequent renewal applications may be required to examine other exposure routes.

This screening approach does not include the methodology necessary to address the human health risk from multipathway exposure to the chemicals listed in Tables 4-1 and 4-2. It also does not address the health risk assessment of radioactive chemicals, which requires specific modeling and health risk assessment calculations to account for radioactive decay.

5.1 PREPARATION FOR ANALYSIS, THE CHECKLIST

Appendix B presents a checklist which should be completed before initiating this screening analysis procedure. This screening analysis requires the following information on each source for the hazardous air pollutants listed in Table 5-1.

Source Type - All solid and hazardous waste incinerators will have at least one point source, the incinerator stack. Some facilities may also include storage tanks or storage piles which can also emit hazardous materials to the air. Incinerator stacks and tank vents can be entered as point sources. Storage piles and other large sources should be entered as area sources.

Emission Rate - For the initial screening analysis, every source at the facility with a potential to emit pollutants of concern listed in Table 5-1 must be quantified and included on the checklist. The dispersion model requires the point source emission rates to be input in terms of grams per second (g/s) and area sources be input as $g/s\text{-}m^2$. Emissions from all sources venting to a common stack should be totaled and the impacts estimated for that common stack. The maximum short-term emission rates should be estimated and reported for each pollutant at each individual source or emitting process within the facility. The total facility emissions for an individual air contaminant are calculated by taking the sum of emissions from each source or process for that specific pollutant. The hours of operation for each source must be included in the calculation of facility emissions and also included in the permit application.

Emission rates can be estimated by either source testing at a similar facility, or by calculating emission rates using a mass balance approach or approved emission factors. Source testing provides the most accurate emission rates but must be conducted on similar equipment and can be very expensive. Emission rates can also be developed by conducting a mass balance analysis using the quantities of process materials and the destruction and removal efficiency of the incinerator. Finally, sources and documents, including the EPA database FIRE and EPA's AP-42, *Compilation of Emission Factors*, (1977, 1990d, 1993d) provide emission factors which are combined with operating parameters to conservatively estimate emission rates.

Height of Release Above Ground - The release or stack height above ground-level for each source must be determined. The dispersion models require this information in meters above ground surface.

Stack Diameter - The inside diameter of the stack at the exit point is needed. This information is given in meters. In a situation where multiple flues are contained within one stack, an effective stack diameter representing the area of all flues combined may be calculated and used to model all flues as one point source. For area sources the source is assumed to be square and the length of one side is entered into the model.

Stack Gas Exit Velocity - The gas flow rate or discharge in actual cubic feet per minute (ACFM) and discharge direction are reported on the checklist. For a horizontal or down discharge direction, or for stacks discharging upward but covered by a raincap, a low stack gas exit velocity and appropriate diameter which conserves the actual volumetric flow rate should be input. The exit velocity can be calculated by dividing the volumetric flow by the cross-sectional area of the stack. When modeling multiple flues as one stack the stack gas exit velocity should be calculated using the effective stack diameter and the total gas flow rate or discharge of all flues combined. The modeling units are meters per second (m/s). Refer to the EPA (1992b) for details of these calculations.

Stack Gas Exit Temperature - The stack gas exit temperature is shown in the checklist (Table B-1). It is preferable to use the lowest temperature listed. The dispersion model requires stack gas exit temperature in °K, which is the temperature in °C + 273 °K.

Nearest Distance to Property Line - If public access to the facilities property is restricted by a fence or other means, calculate the distance between the point or area source and the nearest facility property boundary line. For area sources, this distance should be measured from the center of the area source, not the edge. This location should be input to the SCREEN2 model as a discrete receptor location.

Dimensions of Nearby Buildings - Downwash effects from nearby buildings or structures need to be accounted for when modeling point sources in this screening analysis. The methodology of determining whether a stack is less than the good engineering practice (GEP) stack height, and therefore affected by downwash, is described in detail in the EPA publication *Guideline for Determination of Good Engineering Practice Stack Height* (Revised) (EPA 1985). Emissions from short stacks which are one and a half times the building height or less, have the potential be captured in the cavity recirculation region near the building. To determine if this worst-case condition potentially exist, determine the height or maximum projected width of all solid structures near the stack. For each structure, calculate whether the height or maximum projected width is less, with the lessor value becoming the length L. If the structure is less than 5L in distance from the stack, then the structure has potential to cause downwash of the stack's plume. For every structure satisfying this criteria, calculate the structure's GEP stack height by adding the value of 1.5L to the height of the release height of the point source, then building dimensions should be input into the dispersion model and downwash effects included. Building dimensions of the structure that produces the highest GEP stack height should be used. The SCREEN2 model uses the building's height and maximum and minimum horizontal dimensions.

Complex Terrain - Terrain above stack height may be impacted by emissions from incinerators. The complex terrain option of SCREEN2 allows the user to estimate impacts for cases where terrain elevations exceed stack height. If the user selects this option, then SCREEN2 will calculate and print out a final stable plume height and distance to final rise for the VALLEY model 24-hour screening technique. This technique assumes stability class F (E for urban) and a stack height wind speed of 2.5 m/s. For complex terrain, the maximum impacts are expected to occur where plume impacts the elevated terrain during stable conditions. Therefore, the user is instructed to enter minimum distances and terrain heights for which plume impact is likely, given the plume height calculated, and taking into account complex terrain closer than the distance to final rise. If the plume is at or below the terrain height for the distance entered, then SCREEN2 will make a 24-hour concentration estimate using the VALLEY screening technique. If the terrain is above stack height but below plume centerline height for the distance entered, then SCREEN2 will make a VALLEY 24-hour estimate (assuming E or F and 2.5 m/s), and also estimate the maximum concentration across a full range of meteorological conditions using simple terrain procedures with terrain "chopped off" at physical stack height. The higher of the two estimates is selected as controlling for that distance and terrain height (both estimates are printed out for comparison). The simple terrain estimate is adjusted to represent a 24-hour average by multiplying the one-hour average by a factor of 0.4. Calculations continue for each terrain height/distance combination entered until a terrain height of zero is entered. The user will then have the option to continue with simple terrain calculations or to exit the program. It should be noted that SCREEN2 will not consider building downwash effects in either the VALLEY or the simple terrain component of the complex terrain screening procedure, even if the building downwash option is selected.

5.2 USING THE SCREEN2 AIR DISPERSION MODEL

SCREEN2 runs interactively on the PC, meaning that the program asks the user a series of questions in order to obtain the necessary input data, and to determine which options to exercise. SCREEN2 can perform many single source, short-term calculations, including estimating maximum ground-level concentrations (1-hour averaging time) and the distance to the maximum, incorporating the effects of building downwash on the maximum concentrations for both the near wake and far wake regions, estimating concentrations in the cavity recirculation zone, and estimating concentrations due to inversion break-up and shoreline fumigation. The model can incorporate the effects of simple elevated terrain on maximum concentrations, and can also estimate 24-hour average concentrations due to plume impaction in complex terrain. Simple area sources can be modeled with SCREEN2 using a finite line segment approach. The SCREEN2 model can also calculate the maximum concentration at any number of user-specified distances in flat or elevated simple terrain, including distances out to 100km for long-range transport. The SCREEN2 manual is provided in Appendix A, and should be consulted when using the model.

SCREEN2 is normally executed by simply typing SCREEN2 from any drive and directory that contains the SCREEN2.EXE file, and responding to the prompts provided by the program. When running SCREEN2, the user is first asked to provide a one line title (up to 79 characters) that will appear on the output file. The user will then be asked to identify the source type, P for a point source or A for an area source.

For each point source the user will be asked to provide the following inputs:

Emission rate (g/s)
Stack height (m)
Stack inside diameter (m)
Stack gas exit velocity (m/s) or flow rate (ACFM or m^3/s)
Stack gas temperature (°K)
Ambient temperature (°K) (use default of 293°K if not known)
Receptor height above ground (m)
Urban/rural option (U = urban, R = rural)

For each area source the user will be asked to provide the following inputs:

Emission rate ($g/s\text{-}m^2$)
Release height (m)
Length of a side (m)
Receptor height above ground (m)
Urban/rural option (U = urban, R = rural)

The SCREEN2 model uses free format to read the numerical input data, with the exception of the exit velocity/flow rate option. The default choice for this input is stack gas exit velocity, which SCREEN2 will read as free format. However, if the user precedes the input with the characters VF= in columns 1-3, then SCREEN2 will interpret the input as flow rate in actual cubic feet per minute (ACFM). Alternatively, if the user inputs the characters VM= in columns 1-3, then SCREEN2 will interpret the input as flow rate in m^3/s. The user can input either upper or lower case characters for VF and VM. The flow rate values are then converted to exit velocity in m/s for use in the plume rise equations, based on the diameter of the stack.

SCREEN2 allows for the selection of urban or rural dispersion coefficients. The urban dispersion option is selected by entering a 'U' (lower or upper case) in column 1, while the rural dispersion option is selected by entering an 'R' (upper or lower case) in column 1. For compatibility with the previous version of the model, SCREEN2 also allows for an input of '1' to select the urban option, or a '2' to select the rural option.

Determination of the applicability of urban or rural dispersion is based upon land use or population density. For most purposes in Montana, the SCREEN2 model should be run in the rural mode. Please refer to Section 8.2.8 of the "Guideline On Air Quality Models (Revised)" (EPA 1986a) if it is unclear whether the project is in an urban or rural area.

Figure 1 of the SCREEN2 User's Guide in Appendix A presents the order of options within the SCREEN2 model and is annotated with the corresponding sections from the screening procedures document. In order to obtain results from SCREEN2 corresponding to the procedures in Step 4 of Section 4.2, the user should select the full meteorology option, the automated distance array option, and, if applicable for the source, the simple elevated terrain option. The simple elevated terrain option would be used if the terrain rises above the stack base elevation but is less than the height of the physical stack. These, as well as the other options in Figure 1, are explained in more detail in the User's Guide in Appendix A. A flagpole receptor is defined as any receptor which is located above local ground level, (e.g., the roof or balcony of a building).

A mechanism has been provided to accommodate the fact that for some applications of SCREEN2 the user might want to perform several runs for the same source changing only one or a few input parameters. This mechanism is fully described in the User's Guide in Appendix A.

5.3 USING RISKSCRN

Table 5-1 presents the chemicals most often associated with incinerator emissions and cancer potency, chronic noncancer, and acute noncancer acceptable exposure levels. The FORTRAN program RISKSCRN uses this acceptable exposure data and output from the SCREEN2 model for estimating potential health risk from inhalation of the chemicals listed in Table 5-1. The RISKSCRN Model FORTRAN Code is provided in Appendix C. The executable code for RISKSCRN and SCREEN2 are also provided on the accompanying diskette.

Modeled air concentrations from air dispersion modeling are required for input to the RISKSCRN model. The SCREEN2, 1-hour maximum ground level concentration is used for the acute noncancer risk assessment, while the RISKSCRN model calculates a conservative annual average concentration per instructions in the EPA (1992b) by multiplying the 1-hour concentration by a factor of 0.1 to calculate the annual impact used in the cancer potency, chronic noncancer risk assessment. RISKSCRN also converts the 24-hour complex terrain concentrations to a maximum 1-hour concentration by multiplying by a factor of 4, for acute noncancer risk. This 1-hour concentration is then factored by 0.1 to obtain the annual concentration for the chronic risk calculations.

The chemicals can be entered by CAS (Chemical Abstracts Service) number or assigned a numeric value if no CAS number exists for the compound. The data from Table 5-1 is read by the program from the text file which is provided on the accompanying diskette and titled "CHEM.TXT". This text file can be edited with a DOS screen editor if additional compounds need to be added, or if acceptable exposure levels are changed. The output of the RISKSCRN program is the estimated human health risk for cancer, and the hazard index for noncarcinogenic health effects. The toxicity factors used in this spreadsheet are from the Revised 1992 CAPCOA Risk Assessment Guidelines (October 1993), which include both EPA and the State of California recommended inhalation unit risk factors for cancer and the acceptable exposure levels for noncancer (chronic and acute) health effects, which have undergone public review and comment. The unit risk factors are the estimated probability of a person contracting cancer as a result of constant exposure to an ambient concentration of 1 $\mu g/m^3$ over a 70 year lifetime. The acceptable exposure levels are based on inhalation of 20 m^3 of air per day for a lifetime of 70 years and assume that equal absorption occurs by the inhalation and oral routes of exposure. The assumptions inherent in these unit risk factors and acceptable exposure levels are conservative, and it should be pointed out that other values for these factors and levels exist and may also be appropriate for use.

To execute the program type "RISKSCRN" at the DOS prompt. The program is interactive, and prompts the user for input. The first prompt is for the name of the directory :\> output file to store the inputs and outputs for the run. Use the DOS convention of no more than 8 characters for the first name, and no more than 3 characters for the extension. The next two prompts ask for a title name for the specific run and the CAS number for the air pollutant of concern.

1) To load the RISKSCRN program, enter the directory where files are located and type 'RISKSCRN' at the prompt.

2) Create a file for the output data by typing directory:\>file name (e.g., C:\AIR\>output1).

3) Enter a descriptive title for the run using less than 80 characters (including spaces) which will print out at the top of the output file.

4) Enter the Chemical Abstract Number of the first chemical in the source emissions. Use the numbers provided in Table 5-1.

5) Enter the modeled ground-level air concentrations estimated by SCREEN2 for the first chemical in units of $\mu g/m^3$.

6) Answer the question 'Y' if air concentration is a 24-hour complex terrain concentration, 'N' if it's not.

7) Repeat Steps 4, 5, and 6 for all chemicals identified in source emissions.

8) Type '0' to terminate data entry when all chemical CAS numbers and concentrations have been entered.

9) Print the output file defined in Step 2.

The output file presents the total estimated cancer risk, chronic non-cancer hazard index, and acute non-cancer hazard index for the chemicals emitted from the incineration facility. This is the point where risk assessment ends and risk management begins. An example of the output file RISKSCRN produces is shown in Table 5-2. Various federal and state approaches to defining negligible risk were presented in the July 1993 (WCC 1993) report prepared for the Division. That report concluded that acceptable cancer risk levels typically range from 10^{-4} to 10^{-6}. Use of a conservative, screening-level approach, as presented in this report, typically pushes acceptable risk levels to 10^{-4} or

10^{-5}, although some states use 10^{-6} even with a screening approach. Acceptable chronic or acute non-cancer hazard indices typically range from 0.1 to 1.

This model presented here consists of two parts: a conservative, screening-level air dispersion model and a screening-level risk assessment model for inhalation exposure to chemicals emitted by these facilities. If health risks acceptable to the State of Montana are estimated using this screening-level approach, the State can be fairly confident that potential health impacts due to inhalation have not been underestimated, therefore,no further modeling is required and costs can be kept to a minimum. If unacceptable health risks are estimated, a more refined air dispersion modeling analysis can be conducted by the applicant to reduce the conservatism. A refined modeling analysis will typically cost more to perform, due to the additional data required.

The limitation of the screening risk assessment approach is different. This approach assumes that the chemicals emitted from the facility are volatile chemicals that can only result in health impacts by the inhalation route. If any of the chemicals listed in Tables 4-1 and 4-2 are present in facility emissions, health impacts by exposure routes other than inhalation could occur and potential health risk could be underestimated. In this case, a multipathway health risk assessment must be conducted. Due to the variety of current approaches to conducting this type of assessment, which are discussed in this report, considerable expense could be incurred by the applicant and the State in developing and defending this type of assessment. However, as discussed in the July 1993 report (WCC 1993), exposure to airborne particulate chemicals by exposure routes, such as ingestion of plants and animal products can, in some cases, result in potential health risks equal to or greater than those due solely to inhalation exposure. Therefore, the potential health impacts of the chemicals listed in Tables 4-1 and 4-2 should be evaluated through a multipathway assessment if present in facility emissions. A suggested approach for multipathway health risk assessment can be found in the State of California CAPCOA ACE 2588 Computer Model, California Air Resources Board HRA Program (March 1992, Version 1.1), and CAPCOA Revised 1992 Risk Assessment Guidelines (October 1993). The ACE model incorporates air dispersion modeling, while the HRA Program requires modeling results as input.

Appendix D contains copies of the operating instructions for the California Air Resources Board HRA Program (March 1992, Version 1.1) and the risk calculation algorithms from the CAPCOA Revised 1992 Risk Assessment Guidelines (October 1993). According to CARB and CAPCOA, the algorithms from the CAPCOA guidelines are used in both the ACE and HRA programs. The guidelines were recently revised, and a new version of the HRA program will be available in several months which will incorporate the changes made to the guidelines.

SCREENING RISK ASSESSMENT FOR INHALATION PATHWAY CHEMICALS

Chemical Abstract Service (CAS) Number	Chemical Name	Cancer Potency 1/(ug/m^3)	Chronic Noncancer Reference Exposure Level (ug/m^3)	Acute Noncancer Reference Exposure Level (ug/m^3)
75070	Acetaldehyde	2.70E-06	9.00E+00	
107028	Acrolein		2.00E-02	2.50E+00
79061	Acrylamide	1.30E-03	7.00E-01	
107131	Acrylonitrile	2.90E-04	2.00E+00	
7664417	Ammonia		1.00E+02	2.10E+03
7440382	Arsenic	3.30E-03	5.00E-01	
7784421	Arsine			1.30E+02
1332214	Asbestos	1.94E-04		
71432	Benzene	2.90E-05	7.10E+01	
92875	Benzidene	1.40E-01	1.00E+01	
56553	Benz(a)anthracene	1.70E-03		
205992	Benzo(b)fluoranthene	1.70E-03		
207089	Benzo(k)fluoranthene	1.70E-03		
50328	Benzo(a)pyrene	1.70E-03		
100447	Benzyl chloride		1.20E+01	5.00E+01
7440417	Beryllium	2.40E-03	4.80E-03	
542881	Bis(chloromethyl)ether	1.30E-02		
7726956	Bromine		1.70E+00	
50	Bromine pentafluoride		1.70E+00	
106990	1,3-Butadiene	1.70E-04		
7440439	Cadmium	4.20E-03	3.50E+00	
56235	Carbon tetrachloride	4.20E-05	2.40E+00	1.90E+02
7782505	Chlorine		7.10E+00	2.30E+01
1	Chlorinated dibenzofurans	3.80E+01	3.50E-06	
2	Chlorinated dibenzo-p-dioxins	3.80E+01	3.50E-06	
108907	Chlorobenzene		7.00E+01	
67663	Chloroform	5.30E-06	3.50E+01	
3	Chlorofluorocarbons		7.00E+02	
51	2-Chlorophenol		1.80E+01	
76062	Chloropicrin		1.70E+00	
126998	Chloroprene	1.30E-07	1.00E+00	
18540299	Chromium	1.40E-01	2.00E-03	
4	Coke oven emissions	6.20E-04		
7440508	Copper		2.40E+00	1.00E+01
1319773	Cresols		1.80E+02	
53703	Dibenzo(a,h)anthracene	1.70E-03		
96128	1,2-Dibromo-3-chloropropane	2.00E-03	2.00E-01	
106467	1,4-Dichlorobenzene	1.10E-05	7.00E+02	
91941	3,3'-Dichlorobenzidene	3.40E-04		
117817	Di(2-ethylhexyl)phthalate	2.40E-06	7.00E+01	
123911	1,4-Dioxane	7.70E-06	4.00E+00	2.00E+03
52	Dimethylamine		2.00E+00	
106898	Epichlorohydrin	2.30E-05	3.00E-01	
140885	Ethyl acrylate		4.80E+01	
75003	Ethyl chloride		1.00E+04	
106934	Ethylene dibromide	7.10E-05	4.60E+00	

SCREENING RISK ASSESSMENT FOR INHALATION PATHWAY CHEMICALS

Chemical Abstract Service (CAS) Number	Chemical Name	Cancer Potency 1/(ug/m^3)	Chronic Noncancer Reference Exposure Level (ug/m^3)	Acute Noncancer Reference Exposure Level (ug/m^3)
107062	Ethylene dichloride	2.00E-05	9.50E+01	
53	Ethylene glycol butyl ether		2.00E+01	
54	Ethylene glycol ethyl ether			3.70E+02
55	Ethylene glycol ethyl ether acetate		6.40E+01	
56	Ethylene glycol methyl ether		2.00E+01	3.20E+02
57	Ethylene glycol methyl ether acetate		5.70E+01	
111762	Ethylene glycol monobutyl ether			1.50E+03
110805	Ethylene glycol monoethyl ether		2.00E+02	
111159	Ethylene glycol monoethyl ether acetate			1.60E+03
75218	Ethylene oxide	8.80E-05	6.00E+02	
50000	Formaldehyde	6.00E-06	3.60E+00	3.70E+02
~~999~~ 58	gamma-Hexachlorocyclohexane		1.00E+00	
~~999~~ 5	Gasoline vapors	1.60E-06	2.10E+03	
111308	Glutaraldehyde		1.70E+00	
118741	Hexachlorobenzene	5.10E-04	2.80E+00	
70	Hexachlorocyclohexanes	1.10E-03		
77474	Hexachlorocyclopentadiene		2.40E-01	
302012	Hydrazine	4.90E-03	2.40E-01	
7647010	Hydrochloric acid		7.00E+00	3.00E+03
59	Hydrogen bromide		2.40E+01	
60	Hydrogen cyanide		7.00E+01	3.30E+03
7664393	Hydrogen fluoride		5.90E+00	5.80E+02
7783064	Hydrogen sulfide		4.20E+01	4.20E+01
193395	Indeno(1,2,3-cd)pyrene	1.70E-03		
7439921	Lead		1.50E+00	
108316	Maleic anhydride		2.40E+00	1.00E+01
7439965	Manganese		4.00E-01	
7439976	Mercury		3.00E-01	3.00E+01
67561	Methanol		6.20E+02	
74839	Methyl bromide		6.00E+00	
71556	Methyl chloroform		3.20E+02	1.90E+05
624839	Methyl isocyanate		3.60E-01	
75092	Methylene chloride	1.00E-06	3.00E+03	3.50E+03
593748	Methyl mercury		1.00E+00	
80626	Methyl methacrylate		9.80E+02	
101779	4,4-Methylene dianiline		1.90E+00	
6	Mineral fibers		2.40E+01	
91203	Naphthalene		1.40E+01	
7440020	Nickel	2.60E-04	2.40E-01	1.00E+00
98953	Nitrobenzene		1.70E+00	
61	Nitrogen dioxide		4.70E+02	4.70E+02
79469	2-Nitropropane		2.00E+01	
62	N-Nitrosodiethylamine	1.00E-02		
63	N-Nitrosodimethylamine	4.60E-03		
156105	p-Nitrosodiphenylamine	2.60E-06		
64	N-Nitrosodi-n-butylamine	3.10E-03		

SCREENING RISK ASSESSMENT FOR INHALATION PATHWAY CHEMICALS

Chemical Abstract Service (CAS) Number	Chemical Name	Cancer Potency 1/(ug/m^3)	Chronic Noncancer Reference Exposure Level (ug/m^3)	Acute Noncancer Reference Exposure Level (ug/m^3)
65	N-Nitrosomethylethylamine	6.30E-03		
66	N-Nitrosodi-n-propylamine	2.00E-03		
930552	N-Nitrosopyrrolidine	6.00E-04		
67	Ozone		1.80E+02	1.80E+02
1336363	PCBs	1.40E-03	1.20E+00	
87865	Pentachlorophenol	4.60E-06	2.00E-01	
127184	Perchloroethylene	5.90E-06	3.50E+01	6.80E+03
108952	Phenol		4.50E+01	
75445	Phosgene			1.20E+01
7803512	Phosphine		1.00E+01	
7723140	Phosphorous		7.00E-02	
85449	Phthalic anhydride		7.00E+03	
75569	Propylene oxide	3.70E-06	3.00E+01	1.00E+03
7782492	Selenium compounds		5.00E-01	2.00E+00
1310732	Sodium hydroxide		4.80E+00	2.00E+01
100425	Styrene		7.00E+02	
8	Sulfates		2.50E+01	2.50E+01
68	Sulfur dioxide		6.60E+02	6.60E+02
9	Tetrachlorophenols		8.80E+01	
69	2,4,6-Trichlorophenol	2.00E-05		
108883	Toluene		2.00E+02	
79016	Trichloroethylene	2.00E-06	6.40E+02	
584849	Toluene-2,4-diisocyanate		9.50E-02	
91087	Toluene-2,6-diisocyanate		9.50E-02	
51796	Urethane	2.90E-04		
75014	Vinyl Chloride	7.80E-05	2.60E+01	
75354	Vinylidene chloride		3.20E+01	
~~999~~ 10	Xylenes		3.00E+02	4.40E+03
7440666	Zinc compounds		3.50E+01	

Source: Revised 1992 CAPCOA Risk Assessment Guidelines (October 1993)

TABLE 5-2

EXAMPLE OUTPUT FILE FOR A HYPOTHETICAL RUN OF THE RISKSCRN PROGRAM

Chemical Compound	Hourly Conc $\mu g/m^3$	Cancer ELCR Chronic	Non-Cancer Hazard Quotient Chronic	Non-Cancer Hazard Quotient Acute
Vinyl Chloride	4.000	3.1E-05	0.0154	0.0000
Ammonia	10.00	0.00	0.0100	0.0048
1,4-Dioxane	100.0	7.7E-05	2.5000	5.0000
Total Risks =		1.1E-04	2.5254	5.0048

EPA acceptable risk limits 1.0E-06 to 1.0E-04 for cancer; <1.0 for noncancer.

ELCR = Excess lifetime cancer risk.

6.0
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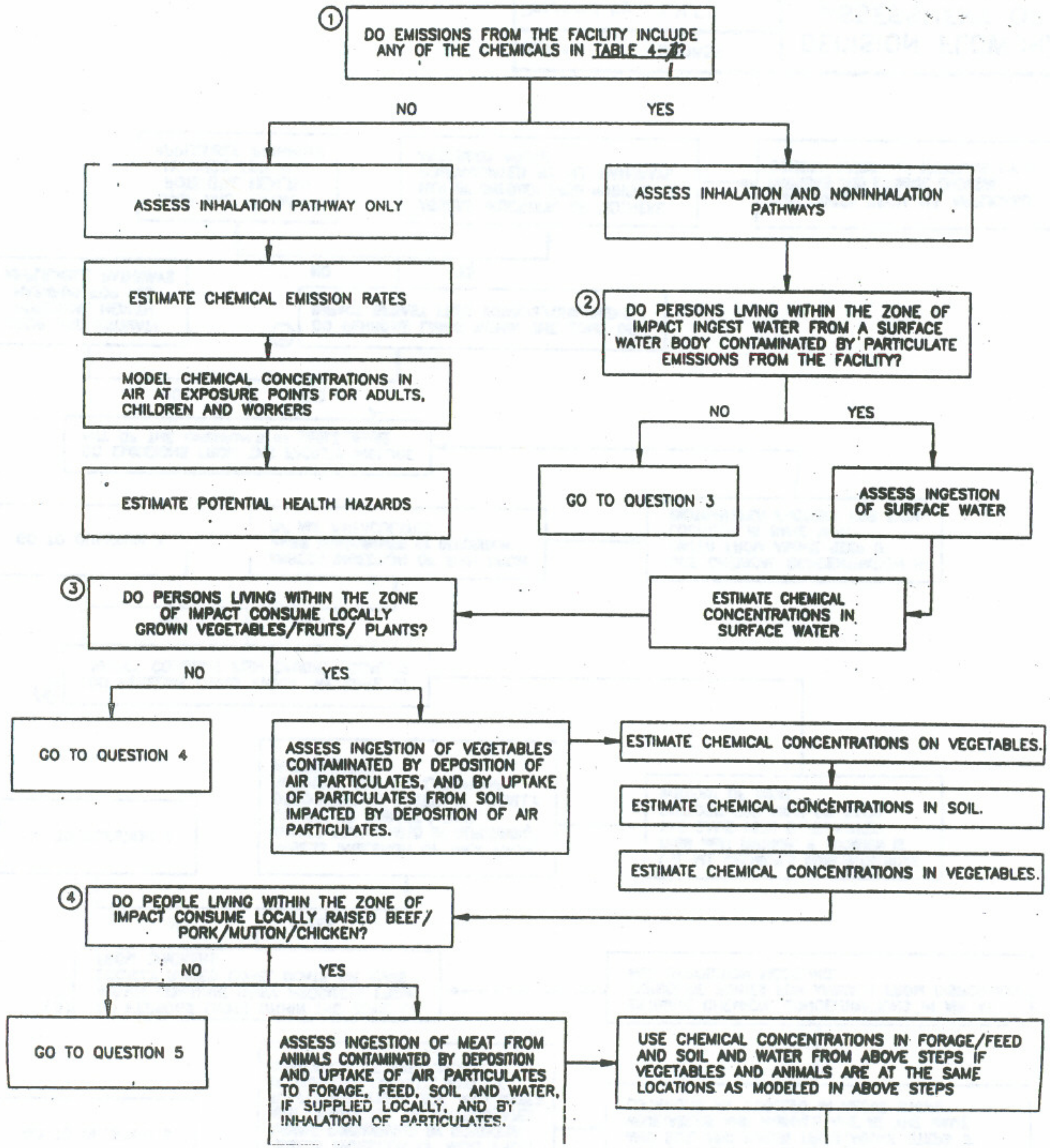
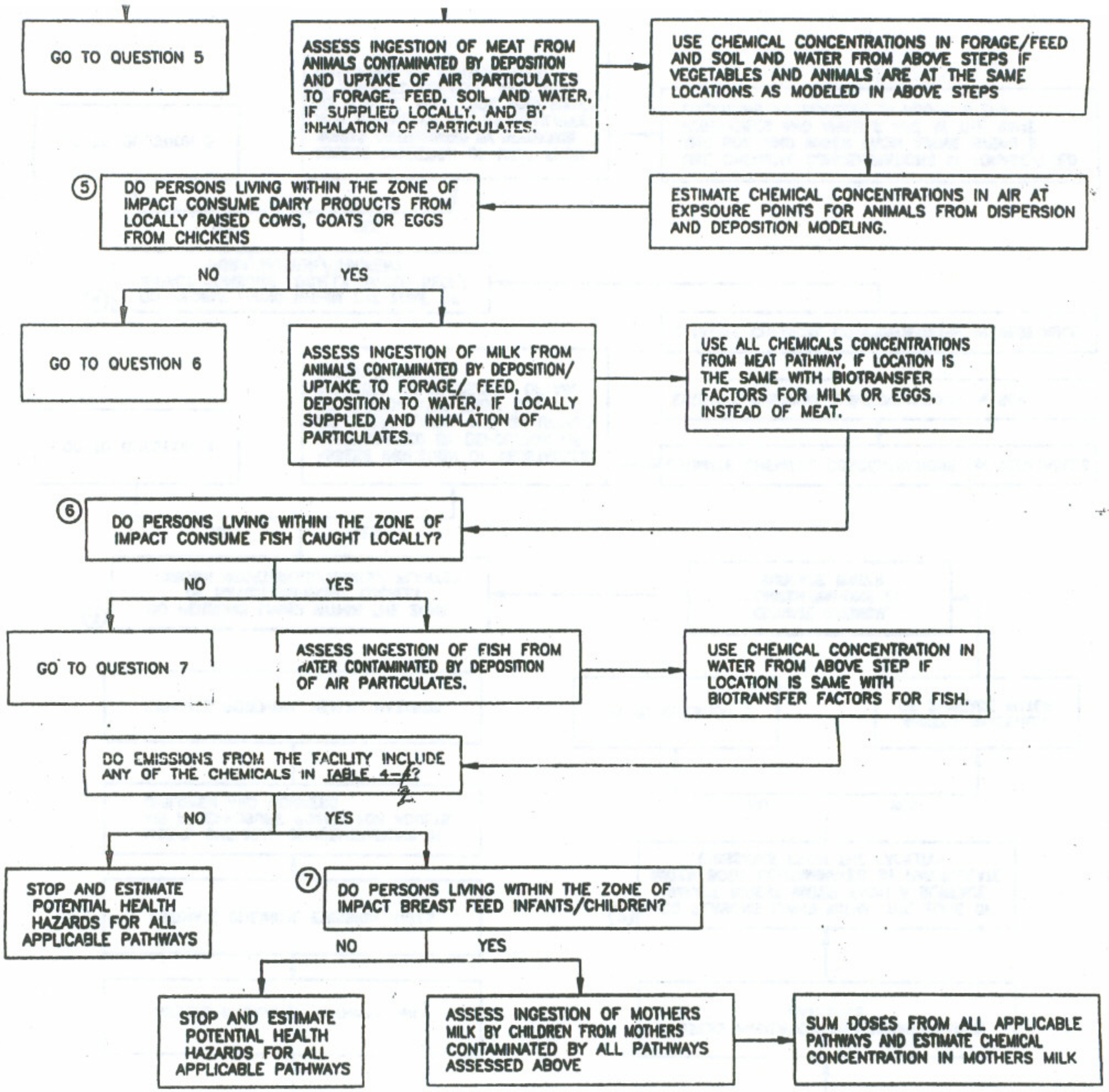

1
DO EMISSIONS FROM THE FACILITY INCLUDE ANY OF THE CHEMICALS IN TABLE 4-1?
NO
YES
ASSESS INHALATION PATHWAY ONLY
ESTIMATE CHEMICAL EMISSION RATES
MODEL CHEMICAL CONCENTRATIONS IN AIR AT EXPOSURE POINTS FOR ADULTS, CHILDREN AND WORKERS
ESTIMATE POTENTIAL HEALTH HAZARDS
ASSESS INHALATION AND NONINHALATION PATHWAYS
2
DO PERSONS LIVING WITHIN THE ZONE OF IMPACT INGEST WATER FROM A SURFACE WATER BODY CONTAMINATED BY PARTICULATE EMISSIONS FROM THE FACILITY?
NO
YES
GO TO QUESTION 3
ASSESS INGESTION OF SURFACE WATER
ESTIMATE CHEMICAL CONCENTRATIONS IN SURFACE WATER
3
DO PERSONS LIVING WITHIN THE ZONE OF IMPACT CONSUME LOCALLY GROWN VEGETABLES/FRUITS/ PLANTS?
NO
YES
GO TO QUESTION 4
ASSESS INGESTION OF VEGETABLES CONTAMINATED BY DEPOSITION OF AIR PARTICULATES, AND BY UPTAKE OF PARTICULATES FROM SOIL IMPACTED BY DEPOSITION OF AIR PARTICULATES.
ESTIMATE CHEMICAL CONCENTRATIONS ON VEGETABLES.
ESTIMATE CHEMICAL CONCENTRATIONS IN SOIL.
ESTIMATE CHEMICAL CONCENTRATIONS IN VEGETABLES.
4
DO PEOPLE LIVING WITHIN THE ZONE OF IMPACT CONSUME LOCALLY RAISED BEEF/ PORK/MUTTON/CHICKEN?
NO
YES
GO TO QUESTION 5
ASSESS INGESTION OF MEAT FROM ANIMALS CONTAMINATED BY DEPOSITION AND UPTAKE OF AIR PARTICULATES TO FORAGE, FEED, SOIL AND WATER, IF SUPPLIED LOCALLY, AND BY INHALATION OF PARTICULATES.
USE CHEMICAL CONCENTRATIONS IN FORAGE/FEED AND SOIL AND WATER FROM ABOVE STEPS IF VEGETABLES AND ANIMALS ARE AT THE SAME LOCATIONS AS MODELED IN ABOVE STEPS



Job No. : 23085E	DECISION FLOWCHART FOR RISK ASSESSMENT OF HAZARDOUS AIR EMISSIONS
Prepared by : S.M.F.	
Date : 12/6/93	

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FIG. 4-1